Essays on Labour Supply, Retirement, and Consumption

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This thesis is submitted for the degree of
Doctor of Philosophy

St Edmunds' College

March 2021

Declaration

I hereby declare that this dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Abstract and specified in the text.

It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Abstract and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Abstract and specified in the text.

It does not exceed the prescribed word limit of 76,000 words.

Taehee Oh
March 2021

Abstract

Title - Essay on Labour Supply, Retirement, and Consumption

Taehee Oh

This PhD dissertation is a study of the individual level behaviour of labour supply, retirement, and consumption in different contexts.

The first chapter studies the importance of intrafamily supports in elderly people's work and retirement choice. I build a dynamic programming model with extended families consisted of elderly parents and their adult-child households who do not live together, are imperfectly-altruistic toward each other and engage in a non-cooperative dynamic game. The two key innovations are allowing both parents- and child-household to provide transfers to each other and investigation of joint decisions making in older people's labour supply, savings, and intrafamily transfer choices.

The structural parameters are estimated using the Korean Labour and Income Panel Study. I find that taking account of inter-vivos financial transfers can provide a better explanation of older people's life-cycle choices and reliance on government supports. The estimated model is used to evaluate the impact of two policies of social security expansion on elderly people's life-cycle choices. First, the expansion of guaranteed minimum income for the elderly results in crowding-out private transfers and unintended redistribution of resources rather than mitigating old-age poverty. Also, the welfare evaluation of policy can be biased if the strategic interaction between family members is not accounted for adequately. Second, the rise in state pension income amount just has a limited effect on older people's work incentives, and the vast amount of intrafamily resource sharing could be partly caused by high elderly poverty.

The second chapter builds and estimates a dynamic model of older people's joint decisions of labour supply, savings, and social security benefit (SSB) application. One new feature of the model relative to the existing literature is that I allow for the selection into self-employment jointly with paid-employment and retirement. Agents

in the model observe their own paid-sector productivity but are uncertain of their productivity in the self-employment sector. However, the learning process enables people to reduce initial uncertainty by observing the performance of their business. The parameters of the dynamic programming model are estimated using the U.S. Health and Retirement Survey. I find that allowing for the transition between paid- and self-employment delays the retirement of older workers. In the counterfactual simulation, I compare the effects of payroll tax-cut and self-employment subsidy program and find that these policies can contribute to strengthening security in retirement and have a large effect on the proportion of people who choose paid- and self-employment. However, they have limited effects on elderly people's retirement choice.

The third chapter is co-authored with Kai Liu, Shawn Ni and Youn Seol. We estimate the wealth effect on consumption by exploiting the differential effect of housing price booms and busts across households with different holdings in housing wealth. We also extend the analysis of the wealth effect from the consumption growth to its inequality by allowing income shocks and the ability to smooth consumption against income shocks to vary over housing wealth and housing market-driven wealth shocks. Using household-level panel data on consumption, income, and wealth from the Korean Family Income and Expenditure Survey, we find that the house price change has a significant and large differential effect on consumption growth, and homeowners exhibit a stronger ability to insure consumption against income fluctuations. Also, the ability to insure consumption against income risks is imperfect, and the effect of transitory shocks on consumption is smoothed more than that of permanent shocks.

Acknowledgements

I am privileged and deeply grateful for my supervisors, Kai Liu. He has provided me with all the support, guidance and encouragement throughout my PhD journey, and my academic and professional development have flourished on account of their generous input. I have learnt so much from him. I would like to thank Christopher Rauh, Eric French, Hamish Low, Weilong Zhang, and many members of the empirical microeconomics group for their invaluable advice and help. Furthermore, my co-authors, Kai Liu, Shawn Ni, and Youn Seol, are excellent researchers to work with. My PhD colleagues have contributed greatly through their academic support and friendship. I have learned different things from Benjapon Prommawin, Jang Youn Lee and Salvatore Lattanzio.

I sincerely acknowledge the financial support from the Faculty of Economics and the Bank of Korea Fund, as well as IT and administrative support from Craig Peacock, Louise Cross, Jake Dyer, and Silvana Dean.

Finally, needless to say, I thank my family. Without them, I would not be in the position and have the chance to study at Cambridge.

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Chapter 1

Intrafamily Altruism and Inter-Vivos Financial Transfers: Estimating A Dynamic Model of Labour Supply and Retirement

1.1 Introduction

Population ageing is an important social issue observed widely in many countries, around the world. In most OECD countries, people are staying in the labour force longer than ever before. In order to explain elderly workers' labour force participation (LFP) choice, many studies have focused on the increase in life-expectancy, improvement in health status, and demographics such as rising average educational attainment or widening inequality (**??**). In particular, much attention has been devoted to the role of changes in social security rules because the transition from work to retirement is concentrated at the pension entitlement age (**??**).

These studies also have made significant contributions to understanding elderly people's incentives to save and show the importance of intergenerational resource allocation which occurs in the form of bequest. However, a bequest is not the only factor that captures intra-family linkage. Comparing it with patterns of intergeneration transfers which take the form of a one-time bequest at the time or near the time of death, inter-vivos transfers during the lifetime tend to take place more frequently, and a vast amount of resources is being transferred in the form of inter-vivos financial transfers (IVFT). However, retirement literature is silent on the potential connection between elderly people's LFP choice and IVFT between parents and children.

While some structural studies have examined both life-cycle choices and IVFT, they do not model retirement choice and have mainly devoted to unidirectional transfers (either downstream (from parents to children) or upstream (from children to parents)). In reality, however, upstream transfers are widely observed in real-world data as the reverse flow between family members does. Moreover, considering the fact that the need for financing resources to support their children or having an additional source of income from other family members are closely associated with older workers' labour force choice, it is important to study their work and retirement behaviour, together with bidirectional IVFT choice.

The aim of this paper is to investigate how bidirectional IVFT have effects on elderly people's labour supply decision and their security in retirement in a game structure. The first innovation of my model is that I allow not only parents but also children to make transfers toward each other. The second is providing a framework for investigating joint decisions of labour supply, savings, and intrafamily transfer choices. I derive a Markov-Perfect Equilibrium (MPE) of altruistically linked family members who live finite horizon and play a dynamic non-cooperative inter-generational game. In order to capture important aspects of intra-family interaction and yet keep model tractability, I focus on bilateral financial transfers between parents- and child-couple households who do not live together and have a different extent of altruism toward the other party in the same family.[1] Each household in the model independently decides its own household-specific choices at the same time, so one party cannot affect the other party beyond the impact caused by its own choice of financial support.

Under the assumption of non-cooperative simultaneous move game structure and imperfect altruism toward the other household in the same family, this study shows that it is optimal for at most one party to provide net-IVFT under the pure strategy MPE.[2] As a result, the model covers both types (downstream and upstream) of IVFT and allows for three kinds of equilibria: (1) no one provides support (corner solution), (2) only parents make transfers (interior solution of parents) and (3) only upstream transfers are made by a child (interior solution of a child). Thus, this study does not predetermine who will become a donor, recipient or neutral of IVFT, and one of the above equilibria is endogenously decided by interactive optimization between parents- and child-household. Moreover, as the model assumes that individuals are altruistic toward other family members, it characterizes the

[1] *i.e.* Among diverse kinds of within family supports, this study concentrates on intergenerational financial net-transfers and bequests that take place within a family.

[2] The amounts of net-transfers denote the gross provision minus the gross receiving amounts of IVFT. Unless specified otherwise, IVFT always imply a net-amount of financial transfers, henceforth.

positive correlation between each member's economic capacity and the likelihood as well as the size of transfers.

I estimate the model on the longitudinal data from the Korean Labour and Income Panel Study (KLIPS) because South Korea (henceforth Korea) provides particularly suitable settings to study families' decisions on labour supply and IVFT. First, Korean data provide relatively rich patterns of both upstream and downstream IVFT, so it is suitable to study the relationship between inter-vivos transfers and elderly labour supply. Second, KLIPS tracks split-offs who have moved out of the original household, and each interview is conducted along with the original households. Thus, it allows for constructing the sample of families through matching non-cohabitant children to their parents. Third, due to negligible public social security spending and pre-mature pension, elderly people are less likely to be affected by the pension scheme.[3] Thus, the analysis can be more focused on elderly people's labour force choice and transfer decisions. Finally, as a much higher proportion of elderly Korean people aged 55 or more participates in the labour force than that of the OECD average, it provides a suitable environment to study elderly people's work and retirement choice near the end of their career (figure 1.2).

The constructed model adequately reproduces important features of family members' life-cycle choices observed in the data, and in particular, the model can propose an answer to the question that literature has not answered on what it is that becoming donors or recipients of IVFT is related to elderly people's work and retirement choice. The estimated model is used to conduct two counterfactual analyses. The first experiment is to conduct policy analysis. This study performs two sets of policy counterfactuals; one is an expansion of the maximum amount of non-contributory guaranteed minimum income, and the other is an increase in the amount of national pension income.[4] It is assumed that such a change in the economic environment is known for all family members at the beginning of the model period.

The policy counterfactual of guaranteed minimum income expansion for the elderly suggests three important findings. First, the effectiveness of the government transfer programme could be hugely dampened in countries where intergenerational family insurance is widely observed. A unit increase in mean-tested benefit causes a 0.36 unit reduction in the pre-existing private transfers. Thus, the policy results in

[3] On average in OECD countries, tax, and public transfer systems decrease the relative poverty rates of people aged 66 or higher from 68% to 13%, however, in Korea, they just decrease the rate by 1.2%p (**?**).

[4] This study utilizes a partial equilibrium model of work and retirement choice, so it does not go into details about the linkage between the policy implementation and the source of the government's budget financing.

partly crowding-out private transfers and redistribution of resources from parents and government to children rather than having the intended effect of alleviating senior poverty.[5] Second, the expansion causes a sharp increase in the proportion of elderly people who rely on support. As a result, one-unit rises in the maximum amount of mean-tested benefits increases the yearly average amount of government benefit payments each household receives by 0.46 units. Finally, the impact of the increase in guaranteed minimum income on elderly people's work incentives is relatively small.

Several interesting results also emerge from the policy counterfactual of changes in the state pension income amount. First, the rise in benefits has a limited effect on the labour force choice as strategic behaviour between parents and children is accounted for. The second is that a unit increase in contributory benefits causes a 0.22 unit reduction in the pre-existing intrafamily transfers. This implies that the large amount of intrafamily resource sharing observed in the data could partly stem from the relatively high elderly poverty rate. Third, there is no or just limited substitutability between pension benefits and precautionary savings, so the rise in retirement benefits does not discourage elderly people's incentive to save.

The second experiment is to quantify the contribution of intrafamily resource allocation to elderly people's labour supply, asset holdings, and reliance on government supports by solving an alternative model which does not allow for IVFT in any direction. This implies that older people now make the best possible choices under the constraint that they directly face, and there is no interaction with a child.[6] In order to reflect such model environmental and potential behavioural changes, the set of preference and wage process parameters is newly estimated in the context of the model excluding IVFT.

Although the model without strategic interaction still reasonably accounts for older people's patterns of life-cycle choices, the elderly under the alternative model leave the labour force more gradually, so 2.1%p more elderly people under the alternative model participate in the labour force on average than those under the full-model. Also, older parents under the alternative framework are more reluctant to use their precautionary savings. Thus, they hold 20.7% more assets on average than those under the full-model as they cannot rely on insurance from family members. This alternative model demonstrates that the welfare evaluation of policy counterfactuals can be biased if the strategic interaction within a family is not

[5]These imply that the elderly can derive a higher present value of lifetime utility as the government introduces the policy. However, the existing private insurance channel is partly substituted with government benefits.

[6]Similar to other typical structure models of retirement (**???**), parents still value bequests of assets when they die.

accounted for adequately.

The remainder of the paper is organized as follows. Section 1.2 reviews the related literature. Section 1.3 describes the data and patterns of two-sided IVFT. The dynamic model is presented in section 1.4. The identification and estimation strategy is explained in section 1.5. Section 1.6 provides the parameter estimates and the overall model fits. Section 1.7 focuses on counterfactual regimes, and section 1.8 concludes.

1.2 Related Literature

This paper contributes to the knowledge that is required to understand the relation between bidirectional IVFT and older people's choices in the latter part of life.

First, this study expands upon models of work and retirement choice of elderly people by incorporating extended family interaction. The retirement literature has particularly devoted to capturing the dynamics of the labour supply, asset accumulation and health transition near the end of their career (**????**). Typical retirement models assume that individuals purely pursue a strategy to maximize their own self-interest and do not consider the non-market factors. However, the investigation of IVFT is particularly important in relation to parental labour supply. For example, in the case of providing transfers from parents to children during their lifetime, these additional expenditure is needed to be financed, and the most obvious source of income comes from an increase in the extensive margin through delaying the timing of retirement (**?**). On the contrary, receiving transfers from children would encourage parents to leave the labour force earlier. With regard to these channels, little is known whether the elderly actually adjust their work and retirement choice when they need to finance or become a recipient of IVFT.

Moreover, this study complements the literature that analyses the role of extended family insurance and adds knowledge to understanding the additional channels which affect older people's lifetime choices. Ageing individuals face a diverse source of risks, and these risks can stem not only from themselves but from their children. Elderly people's capacity for responding to the risks and how well they are insured depends on other family members as well as their own ability.[7] In the countries which have well-developed public old-age insurance, the majority of IVFT flows from parents to offspring. In order to reflect such an empirical regularity, researchers' interest mainly concentrates on the downstream intra-household allocation of family resources. To give it another way, the literature has focused more

[7]The goal of family supports is to promote the welfare of its members through providing a range of supportive resources which include informal as well as formal support (**???**).

on the special case of intra-family relation and has paid relatively little attention to the dynamic interaction between altruistic family members.[8] To the best of my knowledge, the model framework suggested in this study is among the first to capture the effect of the interaction of extended family members' bidirectional financial transfers on older people's retirement behaviour in a dynamic life-cycle framework. Thus, it contributes to synthesize two series of literature that have evolved separately from one another.

Second, this study contributes to add knowledge on the research which aims at understanding the motivation of intergenerational resource sharing. One of the important issues in the relevant literature is the motivation behind intergenerational transfers choice. There is a lack of clarity about the motives, however, the two most widely accepted explanations are altruism and exchange. Under the altruistic incentive, transfers occur if the welfare of one party is influenced by the other party (**??**). The main prediction of the altruistic model is that transfers are positively related to the economic resources of providers and negatively associated with the financial abilities of receivers.[9] Until now empirical studies using reduced-form models have not provided critical evidence that certainly rejects one of two alternatives. Although they generally support that the amount of transfers from parents to children is an increasing function of parental resources, controversy still remains regarding the relations between the recipient's income and the size of transfers from parents.

For instance, **?** shows that an unemployment spell of young workers largely increases the probability of receiving cash transfers from parents. **?** finds that informal family insurance is widely observed, and negative life-cycle shocks of children such as job separation or divorce can be a good predictor of downstream transfers. These findings are consistent with the prediction suggested by the altruistic model. In this paper, both parties directly derive utility from the other. Thus, I implicitly assume that there is a positive correlation between the donor's economic capacity and the amount of transfers.

To my best knowledge, the model structure suggested by **?** is the only other paper that is directly in line with this study in that they construct a theory for the behaviour of imperfectly altruistic agents who can give transfers to each other.

[8] For example, **?** develops a one-sided altruism model which only allows parents to make transfers for their children. Such a simplification may be permissible in many countries especially areas of western Europe and the U.S (figure 1.1a). In most areas of Asia where nearly half or three-fifth of households provide upstream transfers, however, the one-sided transfer model needs to be adjusted for accommodating empirical regularities observed in these countries (figure 1.1b).

[9] Following the exchange model, on the other hand, IVFT may be made for the party that provides more service either explicitly or implicitly (**??**). Under the exchange model framework, the amount of transfers can be either positively or negatively related to each party's earnings.

They use a continuous model framework without labour income and propose a Markov perfect equilibrium, which allows both agents to save. Thus, their methodology requires well-defined continuous time, and policy functions are needed to be continuously differentiable. In other words, their method cannot be applicable in a framework with a discrete choice. On the contrary, I model elderly people's labour force, especially work and retirement, choice and focus more on the effect of intrafamily interaction on parents-households' security in retirement. In order to achieve these goals and maintain the tractability of the model, I simplify children's labour choice and does not allow the children to save.

With regard to the family interaction from the perspective of competition mode, this study is closely related to the papers such as **???** which introduce a dynamic model with a lack of commitment and cooperation. The great attraction of the non-cooperative framework is that the equilibrium is self-enforcing because each person's behaviour maximizes her well-being.[10,11] Moreover, even if it is always possible for family members to achieve Pareto optimum, non-cooperative outcomes can be regarded as a threat point.[12] To put it another way, although no-commitment may impede cooperation across households and generate inefficiency, the assumption would play a role as a lower bound of family resource allocation or policy evaluation. Thus, it is important to study household decision in a non-cooperative setting to understand household behaviour in a cooperative environment (**?**).

Although it is beyond the scope of this study, it would be worthy to mention that a growing body of research has studied other forms of intergenerational support. In particular, studies on cohabitation has been established to explain the broadly observed cohabitation of extended family members and its underlying motivation. **?** models a dynamic game between a parent and a child over coresidence and shows that the option to move in and out of parental home is an important source of insurance against a child's labour force risk. Also, in regard to the mode of competition, he suggests four reasons why a non-cooperative structure, which causes

[10] **?** argues that the non-cooperative model without commitment is an appealing choice in light of existing empirical evidence on imperfect risk sharing within families.

[11] **?** argues that observable data do not provide sufficient information to identify the size of the Pareto weight using observable data. Therefore, many studies which adopt the collective model simply assume that the relative Pareto weight between two decision-makers is half, and this is an important limitation.

[12] Although cooperative bargains allow for members to achieve Pareto optimum, maintaining particular allocation usually depends crucially on what happens in the event of disagreement known as the "threat point". In other words, the results and prediction from the collective bargaining model heavily rely on the definition of threat points. However, due to legal obstacles and transaction costs, families rarely write explicit contracts governing their behaviour, and it is very difficult to enforce any kind of agreement (**?**).

more theoretical difficulties is preferable.[13] Although I limit the scope of research subject to financial support, the method introduced in this paper can be applied to other forms of intra-family supports.

1.3 Data and Descriptive Statistics

Most variables for this study are drawn from the Korean Labor and Income Panel Study (KLIPS). KLIPS is a labour-related panel survey that comprises cross-sectional and time-series data. It is conducted annually on a sample of 5,000 urban households (original households) and their members.[14] The first wave starts in 1998 with the latest 21st wave completed in 2018. It collects diverse kinds of households' and their members' information including income, consumption, educational attainment, assets, debts, labour market status, and so forth. One of the important advantages of this survey is that it tracks split-offs who have moved out of their parent's household, and each interview is conducted along with the original households. Thus, matching non-cohabitant children to their original household allows for constructing the sample of families which are consisted of parents-child household pair and provides rich information on socio-economic characteristics of both sides.[15]

1.3.1 Sampling Criteria

In this study, data from waves 9-19 (eleven years between 2006 and 2016) of KLIPS are used.[16] Due to the panel household attrition, I start with 4,329 families consisting of 7,102 independent households and 59,143 household-year observations. An observation is dropped from the sample if it cannot satisfy any of the following six criteria: (1) a family consisted of just one household, or parents who form separated households (*i.e.* each male- and female-parent is counted as an independent

[13]First, generating outcomes reflecting the nature of the relation between parents and children. Second, more in touch with reality. Third, due to the limitation on identifying both Pareto-weight and altruism separately, people would face difficulties in using the model to conduct a policy experiment. Finally, it is better to connect with the existing literature.

[14]KLIPS defines a household as a unit of living, which is composed of one or more persons who gather to live together. Household members include not only family members living in the same household but also independently living children who still do not achieve economic independence.

[15]A family in this study is defined by both a group of people currently living together and members who belonged to the original household but now form separate households.

[16]Data from previous waves are not included because the information on financial transfers between parents and children living separately is collected from wave-9. Also, the Korea government has newly introduced various kinds of national employment policies to boost the employment of elderly people since 2017. Thus, considering the difficulty of separating these policy effects from the entire labour force trend, wave-20 and -21 are also excluded from the sample.

household), (2) a parents-children pair with more than one independent child households, (3) a family whose age difference between the male-parent and -child is less than 15, (4) a family composed of single-parent, (5) a family whose independent child household consists of single-adult, and (6) a parents-couple whose male-member is less than 55 years old.[17] Families which do not satisfy all these conditions are included in the sample. The final sample consists of 2,623 yearly observations of 604 parents-child pairs (see table 3.2).

KLIPS contains detailed information on intra-family financial transfers such as the main reason for making transfers and their amount from both the parents- and child-household. However, it does not collect transfer information between parents and children who are living together. Thus, in this study, the analysis is limited to the IVFT between non-coresident household in the same family and ignores the transfers between parents and child who are living together. However, there is a concern about the bias on the results which do not consider the transfers of within household parents-child pairs if there is a correlation between parental coresidence and the amount (or the direction) of support. **?** studies that living arrangement plays a role as a valuable insurance channel. Also, if parents who are willing to endure the disadvantage of living with adult children are more altruistic than parents who do not live together and are more likely to provide both monetary support and non-pecuniary support in the form of shared residence, excluding cohabiting extended families may under-estimate the amount of downstream (from parents to children) transfers.[18]

Although parental coresidence can be used as another important source of intergenerational support that elderly parents give their children, the relative importance of parent-youth living arrangement usually decreases as children become older and get married. Because **?** studies about male youth ranging in ages 17-23 and their option to move-in and -out of the parental home, the relatively large proportion of youth in his study co-resides with their parents.[19] However, the object of analysis in this study is elderly parents approaching the end of their working lives, so children in my sample are older than those in Kaplan's study and less likely to live together with their parents.

For the purpose of comparison, I additionally construct a separate sample of

[17] While families can have more than one non-coresident children, the analysis in this study is restricted to the intergenerational interaction between one-parents couple and one-child household pair. This restriction is introduced for the computational tractability of the model because introducing more than one child-household adds considerable complexity in the strategic behaviours.

[18] Living with adult-children has negative effects on parent's well-being (**?**).

[19] Kaplan shows that 32% and 40% of 22-year-olds youth in the sample live together with their parents and have moved back home.

households which consists of married-parents or -children or both who are currently in a marriage. Figure 1.3a shows that a relatively small proportion of married children live together with their parents after the age of 25, and the proportion decreases rapidly with children's age.[20] Considering the fact that financial support for elderly parents generally increases with children's age (figure 1.3b), this paper can be regarded as a study that analyses within-family interaction that occurs at a later age than those of Kaplan. Also, some literature shows that a selection bias caused by the exclusion of parents-youth living arrangement is not serious. **?** argues that additional consideration on coresidence has a limited effect on the IVFT.

1.3.2 Identifying Major Variables

The labour force participation status shows whether an individual is working or not. In order to avoid the ambiguity that may arise in defining retirement, this study defines a male-parent as a retiree if he is not in the labour force. Thus, anyone who has a formal-job (full-time or part-time) or run their own business (self-employed) is treated as a participant, and no matter what the reason behind it, an individual is categorized as a retiree if he does not fall in the category of participants.[21] Thus, it means that this study does not distinguish between involuntary unemployment and retirement.[22] Also, just 1.4% of male-parent and 1.5% of male-child observations in the sample work as a part-timer. Thus, for simplicity, I assume that parents and children always hold down a full-time job if they work (*i.e.* do not consider a part-time job), and self-employed are not treated separately from paid-workers. Also, if a male-parent and -child work, they are assumed to work 2,500 and 2,250 hours per year, respectively.[23]

The employed persons in KLIPS are divided into two groups: one is paid, and the other is self-employed (non-paid workers). In the case of paid workers, KLIPS requires all paid workers to report their average weekly working hours and collects more than a single measure of the earnings. If respondents are self-employed, the survey does not provide their hours of work and just collects monthly earnings. Thus, there are some limitations in deriving the relation between work and leisure choice. In order to maintain consistency on the measure of labour income, post-tax

[20] On average, 1.44% of observations of parents live with their married children in the separately constructed sample.

[21] Individuals searching for a job or working in a family business without pay are regarded as retired people (labour force non-participants).

[22] This definition is similar to **?**. They do not distinguish between unemployment and non-participation in the labour force.

[23] In the sample, male-parent and -child who have a full-time job work 50.2 and 44.4 hours per week on average, respectively.

yearly earnings of full-time workers and self-employed are used. In addition, all variables measured in money are deflated by the yearly consumer price index of the year 2015.

In this study, the net-amount of across household financial transfers is used to define inter-vivos support.[24] A parents-household (child-household) is defined as making downstream (upstream) IVFT if the amount they provide is greater than the amount that they receive from their child (parents). Thus, the net-transfer amount is the gross provision minus the gross receiving amounts. Also, many small transfers are caused by social customs, and its effect on people's labour force and saving choices would be negligible, so I just consider the occurrence and amount of financial or material support converted in the unit of net currency at least 300,000KRW (*i.e.* net-transfers are left-censored at 0.3 million KRW).[25] Moreover, in order to control the irregular transitory huge amount of support, the amount of transfers is upper bounded at the top 5% of each party's support amounts.

I assume that intra-family resource sharing is incentivised by altruism, and thus provision of IVFT is closely related to the amount of consumption. With regard to the incidence of IVFT motivated by house purchasing, provision funds for business, purchasing durable goods, or repaying debts, however, households do not directly derive utility from consuming them in a given period, but from the flow of services that they provide.[26] Thus, it is assumed that if a household receives durable-IVFT, and the amount of their service flows derived by multiplying the amount of transfers by real-interest rate is greater than 0.3 million KRW, the household receives the amount equivalent to the flow of service as per-period IVFT since the year the household received the corresponding amount of net-transfers.[27] The sample shows that 52.4% of yearly child-household observations make IVFT, however, just 13.3%

[24] In the sample, 94% of families answer both of the following two questions: "Have you ever provided economic support toward your children who do not live together since the last survey" and "Have you ever received economic support from your children who do not live together since the last survey". Thus, the possibility of non-response bias would be limited.

[25] Similar to this study, the Survey of Health, Ageing and Retirement in Europe (SHARE) also collects the amount of financial transfers greater than 250 euros (approximately equivalent to 325,000KRW).

[26] The provision of IVFT motivated by these four reasons is called 'durable-IVFT' henceforth. Table 2.3 shows the proportion and amount of downstream and upstream IVFT by the motivation of one-parents and independent one-child couple pairs. Among 11 motivations, the proportion of downstream and upstream transfers provided for durable-IVFT just accounts for 5.6% and 0.8% of the transfer provision incidence, respectively. Except for these, all other 7 motivations can be broadly categorized as the support for maintaining daily life.

[27] If the calculated flow of services is less than the truncation criterion, such durable-IVFT is assumed as one-off support, and thus the total amount is consumed in the given period.

of parents-household observations support their child couple.[28,29] The summary statistics of the parents- and child-households are given in table 2.1.

1.3.3 Empirical Evidence on Two-Sided Inter-Vivos Financial Transfers

This subsection shows the likelihood and average amount of two-sided IVFT between 2006-2016. Also, using the simple Seemingly Unrelated Regression (SUR) model, I provide a preliminary understanding of the factors associated with the incidence of two-sided IVFT.

Likelihood of providing IVFT: Figure 1.4a shows the direction of financial support by male-parent's age. In both directions of supports, they present a clear trend by age: relatively older parents are more likely to receive support and less likely to become a donor. Since the age of 70, the proportion of parents receiving support has increased remarkably. After the mid-70s, over 70% of them received IVFT from their child. On the contrary, the fraction of parents providing supports decrease with age as more parents leave the labour force, and insufficient pension benefits cause them to dis-save their wealth.

Figure 1.4b captures the relation between parents' labour supply and the incidence of IVFT. The horizontal axis shows the combination of within parents-household labour force participation status. For example, Work-Retire denotes an elderly couple consisted of a working husband and a non-working spouse. There is a clear trend in providing and receiving transfers in relation to parents' working conditions. The transfer rate of the parents-group whose husband participates in the labour force is higher than those of couples whose husbands do not work, and the receiving rate shows the opposite trend. These also capture the life-cycle dynamics

[28] The final sample in this study shows that 74.8% of child-households and 38.5% of parents-households make gross IVFT (counting all the incidence of transfers), and these results correspond to the incidence of IVFT that are observed in other data sets. For example, the Survey of Living Conditions and Welfare Needs of Korean Older Persons in 2017 shows that among elderly people whose age is 65 or over and who have one independent child, 80.6% (28.2%) of them have received (provided) non-regular financial support from (toward) their child. Also, **?** uses the National Research Foundation of Korea in 2009 Regarding Inter-Generational Resources Transfer and Preparation for Latter Life of Middle-Aged Households and suggests that 62.2% of parents received financial supports from their married independent children, and 38.9% of parents made downstream transfers. These two different sources of statistics show that the sample in this study captures the reality of intergenerational transfer choices between parents and independent children households in Korea properly.

[29] Conditional on the households, which provide IVFT toward the other party in the same family, the amount of total transfer provision accounts for 16.9% and 8.8% of working male-parent's and -child's yearly earned income.

of individuals' work and retirement decision. As people become older, they tend to spend more leisure, and declining participation in the labour force leads to a drop in the economic capacity for providing transfers and an increase in the need for supporting them.[30] These results support the necessity of treating the decisions on IVFT in the context of dynamic framework and validity of altruistically motivated transfers.

Figure 1.4c and 1.4d break down figure 1.4a by parents' wealth quartiles with two age groups: 55-66 (Group A) and 67 or over (Group B).[31] These figures show how parents' wealth is correlated with the likelihood of providing and receiving transfers. Figure 1.4c confirms the clear relationship between parents' economic capacity and the likelihood of support toward their child. Moreover, this relationship does not change with age. Among people in group A, just 12.4% of parents in the bottom quantile make IVFT, while 30.5% of parents in the top quantile become a donor. The trend is more apparent for parents in age-group B. Only 1.6% in the bottom quantile make transfers which increased more than 19 times (30.9%) for the parents in the top quantile. Figure 1.4d shows that before the age 67, there is a weak relationship between parents' wealth and the likelihood of upstream transfers, however, for the parents in group B, there is a negative relationship between parents' economic capacity and upstream transfers.

Figure 1.4e and 1.4f show the proportion of downstream and upstream transfers by male-parent's earnings quartile. As expected, the results of downstream transfers are equivalent to figure 1.4c. Regardless of age groups, there is a positive correlation between the amount of earned income and the likelihood of transfer provision. 35.7% of parents aged 55-66 in the top earnings quantile support their child-household, and the proportion monotonically decreases for the parents in the bottom (16.3%). Such a trend is more apparent in group B. Among people in group B, 26.9% of parents in the bottom make financial transfers which increase to 54.5% those in the top quantile. However, figure 1.4f shows that such a clear tendency is not observed in the incidence of upstream transfers.

Size of intergenerational financial transfers: Figure 1.5a shows the amount of downstream and upstream transfers conditional on household observations which make transfers toward the other party in the same family by male-parent's age. One of the most noticeable points is that from the age of 70, the average amount of upstream transfers generally exceeds those of downstream transfers. Second, there have been general patterns between parent's age and the average downstream

[30] The average males' age is 63.7 and 69.5 for workers and retired group, respectively.

[31] In order to maintain a sufficient number of observations, the sample is divided into two groups.

transfer amounts. Parents' average cash transfers recorded their peak at the age of late 60s. After then, the amount decreases with age. However, in general, the amount transferred from child-households increases with age. The parents-households aged 55-57 are received 2.5 million which go up to 7.5 million KRW for the age group 82-84.

Figure 1.5b shows that there is a clear negative correlation between upstream transfer amount and parents' labour supply. This confirms that parental income is closely related to the amount of financial supports from their child. However, the average conditional downstream amount does not show a specific trend over parents' labour force status.[32] Figure 1.5c and 1.5d break down figure 1.5a by parents' wealth and earnings quartiles, respectively. These two figures show how parents' economic capacity is correlated with the size of transfers. As expected, there is a negative correlation between upstream transfer amounts and parents' wealth (figure 1.5c). The conditional average for the top quartile is 3.0 million KRW which go up to 4.9 million KRW for the bottom quartile. In the case of conditional average downstream amounts, except for the bottom earnings quartile parents, there is a positive relation between earnings and the size of transfers. The conditional average for the 25-50th percentile is 1.9 million KRW which go up to 4.2 million KRW for the top earnings quartile. It may be caused by the fact that the amounts of support are determined not just by donors' economic capacity but by recipients' needs. For example, if children who have parents in the bottom wealth quantile are relatively economically vulnerable, parents may have incentives to support more for children's welfare. Similar patterns are observed in figure 1.5d. The amount of upstream transfers is negatively associated with parents' earnings. However, there seems to be no pattern between the amounts of downstream transfers and parents' earnings quartile.

Descriptive Regression on Inter-Vivos Financial Transfers: Before executing the structural approach, I provide a preliminary understanding of the factors associated with non-resident family members' intra-family transfer choice. For this purpose, a reduced-form two-equation SUR analysis is adopted.[33] The empirical

[32]The static fixed-effect linear probability model (FE-LPM) of male parent LFP shows that 10% increase in the amount of transfers from child household is estimated to decrease the probability of LFP by 7.5%, and the coefficient is statistically significant at the 1% level. Although the incidence of downstream transfers is associated with the rise in the probability of male-parent's participation, the coefficient is insignificant at the 10% level. This estimation result can be provided upon request.

[33]The SUR consists of regression equations that satisfy the assumptions of the standard regression model. However, **?** argues that the SUR is more efficient than the independent equation-by-equation estimation method because jointly estimated coefficients account for contemporaneous

analysis strategy can be generalized in the following two sets of downstream and upstream transfer incidence regression equations:

$$Y_{it}^p = A_{it}^p \pi_1^p + LFP_{it}^p \pi_2^p + A_{it}^c \pi_3^p + LFP_{it}^c \pi_4^p + X_{it}\beta^p + \tau_t^p + \epsilon_{it}^p \tag{1.1}$$

$$Y_{it}^c = A_{it}^p \pi_1^c + LFP_{it}^p \pi_2^c + A_{it}^c \pi_3^c + LFP_{it}^c \pi_4^c + X_{it}\beta^c + \tau_t^c + \epsilon_{it}^c, \tag{1.2}$$

where Y_{it}^p (Y_{it}^c) is a dummy variable which has the value one if the parents (child) household in a family i makes financial transfers to the non-resident child (parents) household in period t and is equal to zero if not. Thus, two binary decisions yield a bivariate seemingly unrelated linear probability model.[34] $A_{it}^j,\ j \in \{p, c\}$ is the amount of agent j household's log net-asset holdings, and superscript p (c) denotes the parents (child) household. LFP_{it}^j is labour force status dummy which has the value one if the male-agent j participates in the labor force. X_{it} is a set of covariates that abstract parents- and child-household's life-cycle factors. It includes the amount of parents' log national pension income, health condition of male-parent, female-parent's LFP status, male parent's yearly age dummies, female child-household member's LFP status, and time-invariant information about each household members' educational attainment and its interaction effect. τ_t^j is calendar year fixed effects.

The coefficients gained from the SUR are presented in table 1.4.[35] The estimation results well reflect the main findings of **?**: the provision of IVFT is positively related to the economic capacity of providers and negatively related to the income of recipients. These features are more pronounced in conjunction with the observable characteristics of parents-households. Parents who have higher economic capacity are more likely to make IVFT toward their child. The first panel shows that a 1% increase in parental net-asset holdings and male-parent's LFP are associated with the rise in the incidence of downstream transfers by 2.1% and 8.8%, respectively. However, the child-household's resources have a limited effect on the parent's transfer decision, and their coefficients are statistically insignificant in general.

Equivalent results for the probability of IVFT from child to parents are summarized in the second panel. Although the coefficient on the effect of parental net-assets

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correlation in the errors across equations. Thus, SUR provides more precise estimates of coefficients if error terms are correlated across equations.

[34] It is assumed that error terms are contemporaneously correlated: $[\epsilon_{it}^p, \epsilon_{it}^c] \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_p^2 & \rho\sigma_p\sigma_c \\ \rho\sigma_p\sigma_c & \sigma_c^2 \end{bmatrix}\right)$

[35] Considering the estimated high correlation coefficient of the residuals (-0.317) and Breusch-Pagan test result (p-value=0.0000) indicating the possible correlation between the errors of separate equations, the SUR estimation is more suitable than the separate equation-by-equation OLS method.

on upstream transfers has a positive sign, the magnitude of the effect is negligible (0.0039) and statistically insignificant. Thus, contrary to the hypothesis that the upstream transfer decision is strategically made for securing a future bequest from a rich parent, the result is in line with the altruism model and justifies the model framework that will be explained in section 1.4.[36] In addition, the marginal effects of the SUR are consistent with the results obtained from different estimation methods and model specifications.[37]

1.4 Model

In this section, I develop a dynamic programming model of an altruistically linked family. To capture important aspects of intra-family interaction and yet keep the model in a computationally tractable manner, the model assumes that each family consists of one elderly parents-couple (the parents-household with superscript p) and their independent one child-couple (non-cohabiting child-household with superscript c). The model focuses on bilateral financial transfers between the parents- and child-household who do not live together (a couple consists of husband and wife).[38,39] Thus, a child who is living together with their parents is not considered as a child-household but just regarded as a family member who cannot involve in the decision-making process. It is assumed that couples always jointly make decisions and maximize their household utility, so whether a parents-household is connected to a child-couple through a biological son or daughter does not cause any differences.

Both parents- and child-households are assumed that they are altruistic toward each other, however, the extent of their altruism can differ. Each household inde-

[36]**?** show that there is a positive correlation between parental wealth and the incidence of downstream transfers in Botswana.

[37]I additionally find that the signs and magnitude of marginal effects gained from different estimation model (the probit and logit) and specification (capturing the ageing effects through age and age-squared rather than age-dummies) are not sensitive to changes in the model specification, and the relation between variables still holds. This estimation result can be provided upon request.

[38]As the grandparents' choice of looking after grandchildren would be another important issue and needed to be treated properly, there would be a concern about the family structure that this paper focuses on. However, the data show that just 1.8% of grandchildren are living together with their grandparents. Thus, considering additional computational difficulties of introducing the choice of time allocation for looking after grandchildren, it would be acceptable simplification and just has a limited effect on the results.

[39]Although KLIPS does not provide proper information about grandparents' time allocation for their grandchildren, another Korean elderly panel, Korean Longitudinal Study of Ageing (KLoSA), includes this information. Among grandparents who meet the similar sample selection criteria that I use in the study, only 3.6% of grandparents look after their grandchildren. Thus, the problem which can be caused by missing time allocation of looking after grand-children and related money transfers would be limited.

pendently chooses how much to consume and transfer simultaneously, so family members play a non-cooperative and non-commitment simultaneous-move game in each time period.[40,41] One party's decision has an influence on the other's choice, however, any household cannot force the other to make particular choices. To give it another way, one party cannot affect the other party beyond the impact caused by the choice of IVFT and bequests.

In each period t, parents optimally choose consumption c_{it}^{p}, next-period asset holdings A_{it+1}, financial transfers TR_{it}^{p}, and male member's LFP choice, simultaneously.[42] A male-parent who chooses not to participate in the labour force is regarded as a retiree. However, retirement is not an absorbing status, so retired people can return to work in the next period. It is assumed that child-households are not allowed to save, and their labour force status is decided exogenously, so a child-household chooses their amount of consumption c_{it}^{c} and financial transfers toward their parents TR_{it}^{c} in each period.[43] The uncertainty in the model comes from seven different sources; four are related to parents-household and three factors stem from child-household. The parents are uncertain about the changes in health status (including the incidence of death), the existence of non-labour income, stochastic shocks on medical costs and current earnings. The child-household faces uncertainty on his own earned income, husband's labour force status and the existence of non-labour income.

[40]The competition mode in this study can be regarded as a part of a Stackelberg-Nash equilibrium for the strategic interaction between the parents and child because the recipient takes the donor's decision as given. However who becomes a donor (leader) or recipient (follower) is not predetermined but determined simultaneously as a result of optimization, so in this respect, the game is a simultaneous move game. Each party independently pursues a goal to maximize their own expected utility over the remainder of life, and the extent of altruism toward each other as well as relative economic capacity determine who becomes a leader, follower or neutral.

[41]If a party in a family can commit over transfers, she would announce the transfer schedule and follow it as long as the other party satisfies the condition that the donor suggests. As this study adopts the no-commitment assumption, it can reflect rich patterns of strategic transfer behaviour between family members.

[42]Although workers, in reality, can work or retire voluntarily at any time, this study assumed that people aged 79 and over are not allowed to work exogenously. Thus, everybody retires at the age of 79. Also, in both parents- and child-household, it is assumed that the wife's decision on her LFP choice is drawn in a random manner.

[43]It is assumed that male-child always works whenever he receives a job offer or has a job. Also, employed (unemployed) child-workers can be exogenously separated from their current-job (get a job-offer).

1.4.1 Family Type

A time-invariant family type s_i^k is defined as a combination of observed characteristics $(Edu_i \times \Delta_i)$ and unobserved heterogeneity (μ_k):

$$s_i^k \in \{Edu_i \times \Delta_i \times \mu_k\}, \tag{1.3}$$

where i is for family, and k is for unobserved type. The details of each component are explained below.

Observed characteristics: Family background is characterized by its members' educational attainment Edu_i and age difference Δ_i.[44] As this analysis separates two education groups, a family's educational attainment is included in one of the following four categories; $Edu_i \in [(L,L),(L,H),(H,L),(H,H)]$, where the first argument denotes the male-parent's education level Edu_i^p, and the second argument is male-child's education Edu_i^c. With regard to parents-household, an individual who has received a high-school or higher degree is assigned to a high educational attainment group H. If he did not graduate from high-school or has received less education, he is classified as a group L. However, in the case of child-household, the high group is defined as having received two-year college or higher education. Δ_i denotes the gap between the age of male-parent age_{it}^p and -child age_{it}^c (time-invariant initial condition), which captures the difference in economic capacity of child-households at a given male-parent's age and is discretized by three values; $\Delta_i = age_{it}^p - age_{it}^c \in [25, 28, 31]$.[45]

$$Edu_i = \begin{bmatrix} 1 \ \ if \ Edu_i^p = L \ \& \ Edu_i^c = L \\ 2 \ \ if \ Edu_i^p = L \ \& \ Edu_i^c = H \\ 3 \ \ if \ Edu_i^p = H \ \& \ Edu_i^c = L \\ 4 \ \ if \ Edu_i^p = H \ \& \ Edu_i^c = H \end{bmatrix}, \Delta_i = \begin{bmatrix} 25 \ \ if \ age_{it}^c = age_{it}^p - 25 \\ 28 \ \ if \ age_{it}^c = age_{it}^p - 28 \\ 31 \ \ if \ age_{it}^c = age_{it}^p - 31 \end{bmatrix} \tag{1.4}$$

Unobserved heterogeneity: The probability that a family makes any particular choice at a certain time point can be related to both observable and unobservable determinants. If two exogenously identical families continue to make different choices, the behavioural differences may be induced by unobservable characteristics

[44] This study does not include each household members' education choice.

[45] The model period in this study begins from the age 55 of male-parent, and comparing it with male-child workers aged 25 ($\Delta_i = 31$), the yearly income of men aged 28 ($\Delta_i = 28$) and 31 ($\Delta_i = 25$) is 43.1% and 53.4% higher on average.

(??). As failures to appropriately control for the differences across family may cause severe bias, the modelling of unobservable characteristics plays a role in capturing different choices of families who have similar underlying demographic or economic conditions. In order to capture heterogeneous resource sharing response of altruistically linked family members, this study introduces type-specific altruism factors. The use of panel structure data allows for the modelling of unobservable heterogeneity captured by several types of individuals who differ in unobservable permanent characteristics.

For a family, its unobserved type-specific attributes μ_k are given by the combination of η_k and κ_k ($\mu_k = (\eta_k, \kappa_k)$), and there are three different types of family in the model ($\mu_k \in \{\mu_1, \mu_2, \mu_3\}$). The probability that a family belongs to type-k $pr(k|X_i)$ has the multinomial logit form and are expressed by equation (1.5) as follows:

$$pr(k|X_i) = \begin{bmatrix} \frac{exp\left(\lambda_0^k + \lambda_1^k Edu_i^p + \lambda_2^k Edu_i^c + \lambda_3^k I_{\{Sib_i \geq 1\}}\right)}{1+\Sigma_{l=2}^{3} exp(X_i \lambda^l)} & if\ k = 1, 3 \\ 1 - \Sigma_{l \neq 2} pr(l|X_i) & if\ k = 2 \end{bmatrix}, \tag{1.5}$$

where η_k and κ_k reflect the extent of parents- and child-household's altruism toward the other household in the same family which belong to type k.[46]. The vector of X_i contains a constant, family members' educational attainment Edu_i^p &Edu_i^c, and an indicator function $I_{\{Sib_i \geq 1\}}$ which has the value one if the child has one or more siblings who co-reside with parents. These variables reflect economic capacity as well as the necessity of each household's IVFT provision and may be associated with the probability that a family belongs to an unobservable type reflecting its members' consideration of the other party. The parameters λ^1 and λ^3 which decide the probability of a family belongs to an unobservable type are estimated together with other parameters by structure model.

Therefore, there are 36 different types of family in the model, and a family is assigned to one combination of these time-invariant observed and unobserved characteristics at the beginning of the initial model period.

1.4.2 Lifecycle Model for Parents- and Child-Household

In each period of time, the parents-household pursues a goal to maximize its expected utility over the remainder of lifetime by choosing the amount of consumption c_{it}^p,

[46]For example, $\eta_k \geq 1$ implies that the parents who belong to type-k family put equal or higher weight to their child's marginal utility than their own. Although some people may give higher values to their child's satisfaction, it would be problematic in dynamic environments. Thus, this study analyses the case that both parents' and child's intensity of altruism is limited, and thus the extent of both altruism factors are less than one.

hours of leisure l^p_{it}, savings A_{it+1}, and downstream IVFT TR^p_{it} toward their non-cohabiting child for the duration of their life.[47] All the remaining resources are bequested to their child-household once male-parent dies, and parents also derive utility from this accidental bequest $\theta_B \times B(A_{it+1})$, where θ_B is the intensity of parents' bequest motive.[48]

The child aims to maximize its expected utility over the remainder of lifetime by choosing the amount of consumption c^c_{it} and upstream IVFT TR^c_{it} toward their parents. Similar to parents, household dynamics are not considered, and it is assumed that employment is exogenous for the male-child (*i.e.* for the child-household, labour supply is not a choice variable). An unemployed male-child receives a fixed job-offer at a rate $1 - \Lambda_{un}$ (arrival rate of job offers). Once a job offer is given, he always accepts it and works full-time. Also, incumbent male-child workers can be separated from the job exogenously at a rate of Λ_s (job separation rate). If separation occurs, he receives a job offer with the probability of $1 - \Lambda_{un}$ in the next period.

Preference and bequests: Let $U^p_{it}(k)$ denote the parents-household's period t utility for type-k family i consisted of two parts. The parents derive utility from their own consumption and leisure. Also, they derive utility from their child-household (in this altruistic model framework, $\widetilde{u}^p_{it}$ and $\widetilde{u}^c_{it}$ correspond to instantaneous utility). The per-period utility of parents-household is given by:

$$U^p_{it}(k) = \widetilde{u}^p_{it} + \eta_k \widetilde{u}^c_{it} + \epsilon_{it}, \quad \widetilde{u}^p_{it}(c^p_{it}, l^p_{it}) = \frac{\left((c^p_{it})^\alpha (l^p_{it})^{1-\alpha}\right)^{1-\sigma} - 1}{1-\sigma}, \tag{1.6}$$

$$l^p_{it} = \overline{L} - (\overline{h}^p_{it} + \gamma_P) \times I_{\{LFP^p_{it}=1\}} - \gamma_{Fair} \times I_{\{hs_{it}=Fair\}} - \gamma_{Bad} \times I_{\{hs_{it}=Bad\}}, \tag{1.7}$$

where ϵ_{it} denotes a vector of taste shock associated with the discrete labour force choice and is assumed to follow *iid* extreme value distribution. α captures the relative importance of consumption, and the coefficient of relative risk aversion is given by σ (> 0). $\overline{L}$ is time-endowment, and $\overline{h}^p_{it}$ is hours of work. In the solution of the model, a male-parent who participates in the labour force is assigned 2,500 working hours per year.[49] Thus, the LFP choice of male-parent is equivalent to choosing the amount of leisure l^p_{it} to enjoy given health status hs_{it}. $I_{\{\cdot\}}$ is an indicator function, which has the value one if an individual's current state corresponds to

[47] *i.e.* Household dynamics such as divorce, remarriage or living arrangement between parents and children are disregarded.

[48] If a male-parent dies, the simulation is ended at that point, and parents' left assets are all transferred to their child.

[49] *i.e.* If $LFP^p_{it} = 1$ ($LFP^c_{it} = 1$), then $\overline{h}^p_{it} = 2,500$ ($\overline{h}^c_{it} = 2,250$).

$\{\cdot\}$ and the value zero, otherwise. Employment status of male-parent is denoted by $LFP^p_{it} \in \{0,1\}$: employed $LFP^p_{it} = 1$ or retired $LFP^p_{it} = 0$. γ_P captures the time cost that all people who participate in the labour force need to pay. γ_{Fair} and γ_{Bad} are the additional time costs caused by having 'Fair' and 'Bad' health status (hs_{it}), respectively.

Similarly, as the parents directly derive utility from their child, the child is also altruistic toward their parents. The child-household's period t utility for type-k family i is express by $U^c_{it}(k)$:

$$U^c_{it}(k) =\widetilde{u}^c_{it} + \kappa_k \widetilde{u}^p_{it}, \quad \widetilde{u}^c_{it}(c^c_{it}, l^c_{it}) = \frac{\left((c^c_{it})^{\alpha}(l^c_{it})^{1-\alpha}\right)^{1-\sigma} - 1}{1-\sigma}, \tag{1.8}$$

$$l^c_{it} =\overline{L} - (\overline{h}^c_{it} + \gamma_P) \times I_{\{LFP^c_{it}=1\}}, \tag{1.9}$$

where $\overline{h}^c_{it}$ is assigned 2,250 hours per year if the male-child works ($LFP^c_{it} = 1$). This implies that exogenous employment status of male-child directly decides l^c_{it}.

Following **?**, I assume that parents-household's asset holdings is bequeathed to the child-household upon the death of male-parent, and both parents and child derive utility from bequests. The bequest function B_{it+1} has the following functional form:

$$B_{it+1} = B(A_{it+1}) = \frac{(A_{it+1} + K)^{(1-\sigma)} - 1}{1-\sigma}, \tag{1.10}$$

where K determines the extent to which bequests are luxury goods, and thus K decides the curvature of B_{it+1}. If $K = 0$, there is infinite dis-utility of leaving non-positive bequest.

Wage equation: Following the standard **?** earnings equation, the hourly wage rate of the male-parent is given as follows:

$$\begin{aligned} ln\ w^p_{it} =& w^p(X^p_{it}) + \xi^p_{it}, \quad X^p_{it} = \{age^p_{it}, hs_{it}, Edu^p_i\}, \quad \xi^p_{it} \sim N\left(0, \sigma^2_{\xi^p}\right), \\ w^p(X^p_{it}) =& \beta^p_0 + \beta^p_1 age^p_{it} + \beta^p_2 \left(age^p_{it}\right)^2 + \beta^p_3 \times I_{\{hs_{it}=Fair\}} + \beta^p_4 \times I_{\{hs_{it}=Bad\}} \\ &+ \beta^p_5 \times I_{\{Edu^p_i=H\}}, \quad \beta^P = \left\{\beta^p_0, \beta^p_1, \beta^p_2, \beta^p_3, \beta^p_4, \beta^p_5, \sigma^2_{\xi^p}\right\}, \end{aligned} \tag{1.11}$$

where $w^p(X^p_{it})$ is the deterministic part of male-parent's wage which is the function of age, health status and his own educational attainment, and ξ^p_{it} is an idiosyncratic shock. Due to the threat of selection-bias which may occur when observed earnings in the data are only used (*i.e.* earnings of people who choose to work are only observable), the parameters determining earnings process β^P need to be estimated together with preference parameters by structural model.

The logarithm of male-child wage is equal to the sum of a deterministic component $w^c(X^c_{it})$ which is the function of age and his own educational attainment and an idiosyncratic shock ξ^c_{it}. The hourly wage rate of the male-child is expressed by:[50]

$$
\begin{aligned}
ln\ w^c_{it} =& w^c(X^c_{it}) + \xi^c_{it}, \quad X^c_{it} = \{age^c_{it}, Edu^c_i\}, \quad \xi^c_{it} \sim N\left(0, \sigma^2_{\xi^c}\right), \qquad (1.12)\\
w^c(X^c_{it}) =& \beta^c_0 + \beta^c_1 age^p_{it} + \beta^c_2 \left(age^c_{it}\right)^2 + \beta^p_3 I_{\{Edu^c_i = H\}}, \quad \beta^C = \left\{\beta^c_0, \beta^c_1, \beta^c_2, \beta^c_3, \sigma^2_{\xi^c}\right\}
\end{aligned}
$$

Budget set: The budget constrain of the parents-household is given by:

$$
\begin{aligned}
c^p_{it} + TR^p_{it} + oop_{it} + A_{it+1} =& w^p_{it} \times \overline{h}^p_{it} \times I_{\{LFP^p_{it}=1\}} + A_{it}(1+r) + TR^c_{it} \qquad (1.13)\\
&+ NP_i \times I_{\{age^p_{it} \geq \overline{age}\}} \times I_{\{\overline{NP}_i = 1\}} + nl^p_{it} \times I_{\{LFP^{p,w}_{it}=1\}} + TR^G_{it},
\end{aligned}
$$

$$TR^p_{it} \geq 0, \quad c^p_{it} \geq 0,$$

where parents can use their income to purchase consumption goods c^p_{it}, to provide IVFT toward their child TR^p_{it}, to pay medical expenses for survival oop_{it}, and to invest (or savings) in risk-free assets A_{it+1} which earn after-tax interest at a rate of r. The parents-household is assumed to be unable to borrow for their own consumption or providing inter-vivos transfers from the future. Also, they cannot force their child to provide a particular amount of transfers (*i.e.* it is not allowed for the parents-household to decide the negative amount of financial transfers and cannot force the child's household to provide a certain amount that they choose). However, the household net worth at the beginning of each period can be negative if the realization of health costs, and unexpected wage shock causes insufficiency of savings. TR^c_{it} denotes the amount of upstream transfers chosen by their child-household. As it will be explained by proposition 1 in subsection 1.4.4, it is optimal for at most one party to provide IVFT under the pure strategy Markov Perfect Equilibrium.[51,52] NP_i is the amount of National Pension income.[53] For simplicity, I assume that the amount and right to claim the pension are given exogenously ($\overline{NP}_i = 1$ implies that an individual has the right to draw a pension). All elderly people who are

[50]The parameters determining male-child's earnings process β^C is also estimated together with preference parameters by the structural model.

[51]If the extent of each generation's altruism is too high (*i.e.* $\eta_k, \kappa_k \geq 1$), each party wants the other party to have a large portion of family wealth. Thus, too strong altruism causes a conflict in optimal allocation (**?**).

[52]If both households play Markov strategy, then the amount of expected transfers is the same as IVFT that players actually choose.

[53]It also includes the national pension and other types of contributory public pension scheme (special occupational pension) such as government employees pension, private school teacher's pension and military pension.

eligible for claiming pension automatically begin to draw at the age of 61 (*i.e.* $age^p_{it} \geq \overline{age} = 61$) and receive the same amount until death. This implicitly assumes that the choice of the starting point of drawing pension is disregarded. nl^p_{it} denotes non-labour income, $LFP^{p,w}_{it}$ has the value one if the married woman works, and TR^G_{it} denotes the government transfers.[54]

The budget constraint of the child is expressed by:

$$\begin{aligned} c^c_{it} + TR^c_{it} = w^c_{it} \times \overline{h}^c_{it} \times I_{\{LFP^c_{it}=1\}} + nl^c_{it} \times I_{\{LFP^{c,w}_{it}=1\}} + b \times I_{\{LFP^c_{it}=0\}} \\ + TR^p_{it}, \quad TR^c_{it} \geq 0,\ c^c_{it} \geq 0, \end{aligned} \tag{1.14}$$

where b denotes the amount of unemployment insurance benefits which is given to unemployed young workers. Unlike parents-households, the model assumes that child-households are not allowed to save. Although it is a strong assumption and may not be innocuous, there are great theoretical and computational difficulties if it is allowed for both parties to save (Kaplan 2012).[55] With this assumption, it is possible to focus more on elderly people's work and retirement decision in a tractable manner. Also, the empirical evidence from preliminary reduced from analysis which is explained in section 1.3.3 justifies the model assumption; there is a close relation between parents' asset holdings and downstream transfers, however, a child's wealth is not an important determinant of making downstream and upstream transfer choice. Based on this restriction, the child-household's level of consumption is fully determined by the couple's labour force status, b given for unemployed young male-workers, and provision of IVFT from or to their parents.

Health transition and medical expenses: It is assumed that the male-parent's health affects (1) the amount of medical expenditure, (2) leisure time, (3) productivity, (4) survival probabilities, and (5) probability of elderly women's LFP.[56] However, unfortunately, it is impossible to directly observe the actual health status, and only objective and subjective measures of health conditions are available. Despite the growing research on the effect of health on labour force choice, it is still debatable how to measure it. This study follows the method suggested by **?**. I use Principal Components Analysis (PCA) and combine multiple subjective

[54] The functional forms of nl^p_{it}, $LFP^{p,w}_{it}$, and TR^G_{it} are explained below.

[55] **?** points out "the theoretical challenges to working with an imperfectly altruistic model without commitment in which both parties can save are overwhelming. Such models generally have a large set of Markov equilibrium and to date are only understood in very stylized settings" **?**, page 474.

[56] It is assumed that female-parent's health is not considered in this study. Also, the health status of husband and wife in a child-household is implicitly assumed as always 'Good', and young households do not need to pay medical costs.

measures of health status (self-evaluated health, physical constraint and activity of daily living-summary) into one single index hs_{it}. Although this method still has a measurement error problem, it is a parsimonious way as well as mitigating the problems. In each period, the living parent's health is in one of the following three categories: (1) Good (2) Fair or (3) Bad (*i.e.* $hs_{it} \in \{0(Good), 1(Fair), 2(Bad)\}$). hs_{it} evolves stochastically to hs_{it+1} having values Good, Fair, Bad or Dead (*i.e.* $hs_{it+1} \in \{0, 1, 2, 3(Dead)\}$). If a male-parent dies, the optimization process of the family is ended at that point, and all the asset holdings of parents are bequeathed to their child.

The probability of given health to the next period health state depends on the individual's age (including age-squared and -cubed), current health state and his own educational attainment. It is assumed that transition probabilities from one to another state of health are given exogenously, so individuals cannot affect the probability through investment in health care or increase in hours of exercise.[57] The health status transition probabilities are estimated by ordered logistic regression:

$$p_{t+1}^{hs_{t+1}} = pr(hs_{it+1}|age_{it}^p, hs_{it}, Edu_i^p) = \Lambda(hs_{it+1}|age_{it}^p, hs_{it}, Edu_i^p) \tag{1.15}$$

Medical expenses of parents-household m_{it} are defined as out-of-pocket (*oop*) costs in this model.[58] It is assumed as a negative income shock, which should be paid in order to survive, however, the cost has no impact on future medical expenses or health status.[59] Medical expenses are modelled as the function of an individual's age age_{it}^p, asset level A_{it}, health state hs_{it}, and educational attainment Edu_i^p as follows:[60]

$$\begin{aligned} ln\ oop_{it} =& ME(age_{it}^p, A_{it}, hs_{it}) + u_{it} = \beta_0^M + \beta_1^M age_{it}^p + \beta_2^M (age_{it}^p)^2 \\ & + \beta_3^M ln\ A_{it} + \beta_4^M \times I_{\{hs_{it}=Fair\}} + \beta_5^M \times I_{\{hs_{it}=Bad\}} + \beta_6^M I_{\{Edu_i^p=H\}} + u_{it}, \\ & u_{it} \sim N(0, \sigma_u^2) \end{aligned} \tag{1.16}$$

Non-labour income: The household has another possible source of income from the spouse. Considering the fact that the spouse's income can serve as insurance against diverse kinds of shocks, the spouse's earned income needs to be considered in the model. However, introducing joint work and retirement choices between

[57] There are a bunch of research, such as **?**, **?**, **?** and **?**, which introduce similar exogeneity assumption.

[58] Top 5% of oop costs are removed.

[59] I assume that individuals have to make the LFP and the likelihood as well as amount of transfer decisions before observing u_{it} for the period.

[60] Age and age-squared are used. It is assumed that there is a correlation between net-wealth and the quality of care that individuals choose.

the couple impose considerable computational burdens. Moreover, comparing it with elderly men's labour supply, a relatively less proportion of married women participate in the labour force. On average, just 29.6% of married elderly women whose husband's age is between 55-75 participate in the labour force.[61] The situation is similar for child-household. Comparing it with young men's labour supply, a relatively less proportion of married women participates in the labour force. On average, the LFP rate for men whose age is between 30-45 is 96.3% in the sample, while below half (42.0%) of women with 30-45 years old husband are in the labour force.

The income actually comes from the wife's labour supply, however, it is regarded as non-labour income nl_{it}^{j} ($j \in \{p, c\}$) in this study because it occurs regardless of the husband's labour force status. In order to reflect the distinctive characteristics of married women's labour supply and reduce the computational burdens, parameters of post-taxed non-labour income are estimated external to the structural model. It is assumed that the wife's decision on her given period LFP draw happens at the end of each period (*i.e.* after her husband makes labour supply choice, and couples decide the amount of IVFT and savings).[62] The elderly wife's participation is determined by her husband's age age_{it}^{p}, health condition hs_{it}, educational attainment Edu_{i}^{p}, and the amount of household savings A_{it}.[63,64] Also, for computational convenience, it is additionally assumed that non-labour income nl_{it}^{j} is a function of deterministic characteristics (husband's age and education).[65] The expected earnings of the wife who belongs to parents-household are derived by multiplying the probability of

[61]Elderly women's LFP rate in the sample declines rapidly with their age. It decreases from 54.0% at the age of 50 to 7.9% at the age of 70.

[62]It is assumed that once she decides to work, she has a full-time job and works 2,000 hours per year. In the sample, 82.1% of the elderly wife who is in the labour force work as a full-time worker or self-employed and just 17.9% of them have a part-time job. Also, women who have full-time job work 46.0 hours per week on average. Among young wives who have a job, 92.7% of them works as a full-time worker or self-employed (just 7.3% of them have a part-time job), and women having a full-time job in the sample work 42.7 hours per week on average. Therefore, the negative effects of the 2,000 hours per year working full-time worker assumption would be limited.

[63]With the assumption that the age-difference between husband and wife is three years old, the non-labour income function can be interpreted as a function of her age, not of her husband's age

[64]In the sample, if the health status of the husband aged between 55 and 75 is good, fair, or bad, the wife's average LFP rate is 24.7%, 27.2%, and 42.7%, respectively.

[65]Studies of female labour supply usually include the husband's educational attainment as an important explanatory variable. **?** find that women are more likely to switch to market work when their husband has received higher education. Moreover, **?** find that husband's level of education has a positive effect on his wife's wages.

labour force participation p^p_{it} and her earnings nl^p_{it}:

$$E(nl^p_{it}|age^p_{it}, hs_{it}, Edu^p_i, A_{it}) = P\{LFP^{p,w}_{it} = 1|age^p_{it}, hs_{it}, Edu^p_i, A_{it}\} \times nl^p(age^p_{it}, Edu^p_i), \tag{1.17}$$

$$P\{LFP^{p,w}_{it} = 1|\cdot\} = p^p_{it} = \Phi(\beta^{p,w}_0 + \beta^{p,w}_1 age^p_{it} + \beta^{p,w}_2 lnA_{it} \tag{1.18}$$

$$+ \beta^{p,w}_3 \times I_{\{hs_{it}=Fair\}} + \beta^{p,w}_4 \times I_{\{hs_{it}=Bad\}} + \beta^{p,w}_5 \times I_{\{Edu^p_i=H\}}),$$

$$nl^p_{it} = \beta^{nl,p}_0 + \beta^{nl,p}_1 age^p_{it} + \beta^{nl,p}_2 (age^p_{it})^2 + \beta^{nl,p}_3 \times I_{\{Edu^p_i=H\}}, \tag{1.19}$$

where $LFP^{p,w}_{it}$ has the value one if a married woman who belongs to parents-household participates in the labour force and has the value zero, otherwise.

In the case of child-household, her participation and the amount of non-labour income are determined by her spouse's age age^c_{it} and education level Edu^c_i. The expected earnings of a wife who belongs to child-household $E_t(nl^c_{it})$ are expressed by:

$$E(nl^c_{it}|age^c_{it}, Edu^c_i) = P\{LFP^{c,w}_{it} = 1|age^c_{it}, Edu^c_i\} \times nl^c(age^c_{it}, Edu^c_i), \tag{1.20}$$

$$P\{LFP^{c,w}_{it} = 1|\cdot\} = p^c_{it} = \Phi(\beta^{c,w}_0 + \beta^{c,w}_1 age^c_{it} + \beta^c_2 (age^c_{it})^2 + \beta^{c,w}_3 \times I_{\{Edu^c_i=H\}}), \tag{1.21}$$

$$nl^c_{it} = \beta^{nl,c}_0 + \beta^{nl,c}_1 age^c_{it} + \beta^{nl,c}_2 (age^c_{it})^2 + \beta^{nl,c}_3 \times I_{\{Edu^c_i=H\}} \tag{1.22}$$

Government transfers and unemployment insurance programs: In order to guarantee a minimum level of resources ($\hat{y}_{min}$) for elderly people, many governments run transfer programs. For example, the Korea government was introduced the Basic Old-Age Pension Scheme in 2008 and has reformed it as Basic Pension Scheme since 2014. I describe the government transfer program in more detail in Appendix A.1. When the sum of households' disposable and savings income is lower than a certain standard, the government fills the gap between $\hat{y}_{min}$ and converted household's income. Thus, it allows households to secure $\hat{y}_{min}$ amount of resources each year. In this study, I follow **?** and simplify the government transfer rules.[66] The amount of government transfers TR^G_{it} that a parents-household receives is given

[66] In reality, the amount of government transfers also depends on many other factors such as the right to draw an occupational pension, currently receiving a disability pension, or running own business.

by:

$$TR^G_{it} = max\{0, \hat{y}_{min} - y_{inc_{it}} - y_{pinc_{it}}\}, \tag{1.23}$$
$$y_{inc_{it}} = 0.7 \times [max\{0, w^p_{it}h^p_{it} - D_1\} + max\{0, nl^p_{it} - D_1\} + NP_i], \tag{1.24}$$
$$y_{pinc_{it}} = max\{0, r \times [A_{it} - D_2]\}, \tag{1.25}$$

where $y_{inc_{it}}$ and $y_{pinc_{it}}$ are the assessed amount of income and the amount of income converted from each household's net-asset holdings. D_1 and D_2 denote the amount of basic income and net-asset deduction, respectively. I use 2015-year deduction points ($D_1 = 6,000,000$ and $D_2 = 85,000,000$ KRW)

The government also runs the unemployment insurance (UI) program. The UI is characterized by the amount of benefits b which are eligible for unemployed young workers ($LFP^c_{it} = 0$), and the eligibility of benefits is independent of the labour force status of the spouse ($i.e.$ The eligibility just depends on male-child's labour force status). The UI benefits are given by:

$$UI_{it} = \begin{bmatrix} 0 & if\ LFP^c_{it} = 1 \\ b & if\ LFP^c_{it} = 0 \end{bmatrix} \tag{1.26}$$

1.4.3 State Space

Given the survival of male-parent, the state of parents-child household pair in each period is captured by six variables: (1) parents' wealth determined in the previous period A_{it}, (2) the amount of male-parent's expected national pension income NP_i, (3) male-parent's age age^p_{it}, (4) head of parents-household's current period health status hs_{it}, (5) the type of family s^k_i, and (6) child's LFP status (work or not) at the beginning of each period. The parents- and child-households enter every period with a given state χ_{it}. At the beginning of time t, the state variable is common knowledge for all members in the family i. Given χ_{it}, the set of preference parameters θ, type assignment probability parameters λ^1 & λ^3, earnings process β^P & β^C, and data generating process z_{it}, each household seeks to maximize their expected utility over the remainder of lifetime simultaneously.

$$\chi_{it} = \left\{A_{it}, NP_i, age^p_{it}, hs_{it}, s^k_i, LFP^c_{it}\right\}, \tag{1.27}$$

$$\theta = \{\alpha, \sigma, \eta_k, \kappa_k, \gamma_P, \gamma_{Fair}, \gamma_{Bad}, K, \theta_B, b\}, \tag{1.28}$$

$$\lambda^1 = \left\{\lambda^1_0, \lambda^1_1, \lambda^1_2, \lambda^1_3\right\}, \quad \lambda^3 = \left\{\lambda^3_0, \lambda^3_1, \lambda^3_2, \lambda^3_3\right\}, \tag{1.29}$$

$$\beta^P = \left\{\beta^p_0, \beta^p_1, \beta^p_2, \beta^p_3, \beta^p_4, \beta^p_5, \sigma^2_{\xi^p}\right\}, \quad \beta^C = \left\{\beta^c_0, \beta^c_1, \beta^c_2, \beta^c_3, \sigma^2_{\xi^c}\right\}, \tag{1.30}$$

$$z_{it} = \left\{\Lambda_{it}, ME_{it}, E(nl^p_{it}), E(nl^c_{it}), TR^G_{it}, UI_{it}, w^p, w^c, \Lambda_{un}, \Lambda_s\right\} \tag{1.31}$$

1.4.4 Dynamic Intergenerational Finite Horizon Game

In the model, an altruistic family consisted of one parents- and one child-households plays a dynamic non-cooperative inter-generational finite horizon game. Two-way altruism leads to bidirectional IVFT and strategic behaviours in consumption, savings and labour supply. With regard to the information structure of the game, both parents and child enter into each period game with the same state variables χ_{it}, and the set of idiosyncratic independent shocks u_{it}, ξ^p_{it} , ξ^c_{it} is common knowledge in the same family once they are realized. Therefore, they play a complete information game. In order to guarantee the uniqueness of the Markov Perfect Equilibrium (MPE), I impose a particular extensive form of the stage game. Each household optimally chooses its own choice variables at the same time, and the amount of IVFT as well as other choice variables are chosen simultaneously. The optimization results in the role of each household as a donor, recipient or neutral of IVFT endogenously. The recipient takes the donor's decision as given and sequentially chooses his own choice except for transfers. In order to find the solution of the game, I use a backwards induction algorithm which begins to solve the problem at time T (age 90) and working backwards to time 1 (age 55).

As the IVFT provider leads the game, a fatal contradiction occurs if both parents and child can make transfers in the same period. However, below proposition 1 guarantees that it is optimal for at most one party to provide IVFT under the equilibrium path.

Proposition 1. ***Dis-allowance of simultaneous bidirectional transfers in the same period:*** *With the assumption of imperfect altruism ($0 < \eta_k, \kappa_k < 1$), at most one party in a family provides financial transfers in the same period game t*

Proof. The formal proof of the proposition is provided in Appendix A.2 □

By Proposition 1, only one of the following three cases holds at time t: $TR_{it}^{p} > 0$ & $TR_{it}^{c} = 0$, $TR_{it}^{p} = 0$ & $TR_{it}^{c} > 0$, or $TR_{it}^{p} = 0$ & $TR_{it}^{c} = 0$.

Timing of the stages: Each period game is divided into six stages, and the sequence of stages assumed in the model is as follows:
(1) Begins with χ_{it} and ϵ_{it} which are common knowledge for all members in the family i
(2) Both households in the same family simultaneously choose the size of transfers as well as other choice variables at the same time. As proposition 1 ensures that it is impossible for both parties to be IVFT donors, each party makes their own decisions assuming that the other party will not provide transfers. All the households in a given family know which party becomes a donor, recipient or neutral of IVFT as private information does not exist in the game
(3) Once each player's role as an IVFT donor, recipient or neutral is determined endogenously, the game is proceeded in two cases depending on the incidence of IVFT:

Case1: If it is optimal for all members not to provide transfers, there is no additional interaction between households (i.e. each household plays the action which is chosen in stage (2)), and the game just moves to stage (4)

Case2: If it is optimal for a household in a family to provide transfers toward the other party, the recipient takes the donor's decision on the amount of IVFT as given and makes her own choice sequentially. The donor's (denoted j) optimal simultaneous decision of TR_{it}^{j*}, and other decision variables are already chosen in stage (2). The recipient (denoted $-j$) takes TR_{it}^{j*} as given. The recipient's state is now written as $\chi_{it}^{-j} = (\chi_{it}, TR_{it}^{j*})$. Along with χ_{it}^{-j} and $TR_{it}^{-j*} = 0$, the recipient optimally chooses the rest of choice variables[67]
(4) Nature draws an idiosyncratic out-of-pocket cost (u_{it}) as well as independent wage shocks (ξ_{it}^{p} and ξ_{it}^{c}) and determines whether each wife participates in the labour force or not[68]

[67]For example, if it is optimal for the parents-household to provide IVFT, they optimally chooses consumption c_{it}^{p*}, labour supply LFP_{it}^{p*} and the amount of transfers TR_{it}^{p*} simultaneously. The child-household takes TR_{it}^{p*} as given, and thus child's state is given as $\chi_{it}^{c} = (\chi_{it}, TR_{it}^{p*})$. Along with χ_{it}^{c}, the expected level of the child's consumption is automatically determined. If the child-household becomes a donor, the child optimally chooses TR_{it}^{c*}. The state vector of the parent is now given by $\chi_{it}^{p} = (\chi_{it}, TR_{it}^{c*})$. Given χ_{it}^{p} and $TR_{it}^{p} = 0$, parents optimally choose their choice variables.

[68]As the random shocks are drawn by nature after each household makes their choice, the shocks can be integrated out, and this allows for having an analytical solution. Although these shocks are *iid*, and current period choices are not influenced by the realization of time t shocks in this study, these affect the properties of future choice. ξ_{it}^{p} and u_{it} have a direct effect on next period asset holdings and result in the changes of male-parent's next period LFP and the direction of

(5) In accordance with shocks and spousal income, parent's savings A_{it+1} and child's actual amount of consumption c^c_{it} are determined
(6) Nature draws updated value of parent's health status hs_{it}, and the child-household head's next period labour force status is determined; An unemployed child receives a job offer at rate $1-\Lambda_{un}$, and an employed child loses his job with probability Λ_s. In the case that head of the parents-household dies ($hs_{it+1}=3$), the child inherits A_{it+1}, and the game ends. If the head of parents-household survives ($hs_{it+1}\neq 3$), the family moves to the next period game.

Pure strategy equilibrium: This study limits the discussion to pure strategy equilibrium. Under the assumption of complete information, the inter-generational interaction can be categorized as a pure strategy finite horizon game. Thus, I consider Markov Perfect Equilibrium (MPE) which can be regarded as subgame perfect equilibrium of the dynamic game. The pure strategies in MPE is given by the pair of Markov strategy; $s^p_{it}(\chi_{it})$ and $s^c_{it}(\chi_{it})$ where $s^j_{it}(\chi_{it})$ denotes player j in family i would choose in state χ_{it}. Given other player's Markov strategy (s^{-j}_{it}), it is straightforward that player j's Markov strategy s^j_{it} for each state (χ_{it}) provides her the highest possible pay-off which player j can achieve from period game t.

$$s^p_{it}:\chi_{it}\longrightarrow(A_{it+1},LFP^p_{it},TR^p_{it}), \tag{1.32}$$
$$s^c_{it}:\chi_{it}\longrightarrow(TR^c_{it}) \tag{1.33}$$

Recursive form of each family's problems: With regard to the recursive form of each agent's problems, the family index-i and type index-k are suppressed for notational simplicity hereafter. At time T, the male-parent dies at the end of the period with probability 1, so his value function takes the form as follows:

$$V^p_T(\chi_T)=\max_{c^p_T,TR^p_T}\tilde{u}^p_T(c^p_T,\overline{L})+\eta\tilde{u}^c_T(c^{c*}_T(\chi^c_T=(\chi_T,TR^{p*}_T)),l^{c*}_T(\chi^c_T))+\beta\theta_B E_T B(A_{T+1}) \tag{1.34}$$

IVFT. In this sense, transitory shocks also generate changes in behavioural dynamic response and intrafamily interaction.

If $t < T$, the Bellman equation of the parent's problem V_t^p takes the form of:[69]

$$V_t^p(\chi_t) = \max\{W_t^p, R_t^p\}, \tag{1.35}$$

$$W_t^p(\chi_t|LFP_t^p = 1) = \max_{c_t^p, TR_t^p} \widetilde{u}_t^p(c_t^p, l_{t,LFP_t^p=1}^p) + \eta\widetilde{u}_t^c(c_t^{c*}(\chi_t^c), l_t^{c*}(\chi_t^c)) \tag{1.36}$$
$$+ \beta E_t\left[\Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}} V_{t+1}^p(\chi_{t+1})\right] + \beta(1 - \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}})\theta_B E_t B(A_{t+1}),$$

$$R_t^p(\chi_t|LFP_t^p = 0) = \max_{c_t^p, TR_t^p} \widetilde{u}_t^p(c_t^p, l_{t,LFP_t^p=0}^p) + \eta\widetilde{u}_t^c(c_t^{c*}(\chi_t^c), l_t^{c*}(\chi_t^c)) \tag{1.37}$$
$$+ \beta E_t\left[\Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}} V_{t+1}^p(\chi_{t+1})\right] + \beta(1 - \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}})\theta_B E_t B(A_{t+1}),$$

where W_t^p and R_t^p denote the value for parents-household which male-member chooses to work and retire, respectively.

On the basis of household head's time t labour force status, child's problem V_t^c takes the form of:

$$V_t^c(\chi_t|LFP_t^c = 1) = \max_{c_t^c, TR_t^c} \widetilde{u}_t^c(c_t^c, l_t^c) + \kappa\widetilde{u}_t^p(c_t^{p*}(\chi_t^p = (\chi_t, TR_t^{c*})), l_t^{p*}(\chi_t^p)) \tag{1.38}$$
$$+ \beta E_t\left[(1 - \Lambda_s)V_{t+1}^c(\chi_{t+1}|LFP_{t+1}^c = 1) + \Lambda_s V_{t+1}^c(\chi_{t+1}|LFP_{t+1}^c = 0)\right]$$
$$+ \beta(1 - \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}})E_t B(A_{t+1}),$$

$$V_t^c(\chi_t|LFP_t^c = 0) = \max_{c_t^c, TR_t^c} \widetilde{u}_t^c(c_t^c, l_t^c) + \kappa\widetilde{u}_t^p(c_t^{p*}(\chi_t^p), l_t^{p*}(\chi_t^p)) \tag{1.39}$$
$$+ \beta E_t\left[(1 - \Lambda_{un})V_{t+1}^c(\chi_{t+1}|LFP_{t+1}^c = 1) + \Lambda_{un} V_{t+1}^c(\chi_{t+1}|LFP_{t+1}^c = 0)\right]$$
$$+ \beta(1 - \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}})E_t B(A_{t+1})$$

Considering the case $TR_t^p = 0$ and $TR_t^c > 0$. The parents-household takes c_t^{c*}, LFP_t^c, and TR_t^{c*} as given and optimally chooses their own $c_t^p(\chi_t^p = (\chi_t, TR_t^{c*}))$ and $LFP_t^p(\chi_t^p)$ by solving the problem $V_t^p(\chi_t^p) = \max\{W_t^p(\chi_t^p), R_t^p(\chi_t^p)\}$.[70] The child-household knows what level of the consumption and labour supply the parents-household will choose if they chooses a particular amount of transfers. The optimal amount of upstream IVFT TR_t^{c*} is derived by the equation (1.38) if male-child is employed or by (1.39) if he is unemployed at period t. For $TR_t^p > 0$ and $TR_t^c = 0$, the parent's decision process is similar to that of the child and is expressed by the equation (1.35). If $TR_t^p = TR_t^c = 0$, then each household independently chooses their own action.

[69]This study assumes that male-parents are not allowed to work from the age 79, so the value function of parents-household which the age of male-member is 79 or more can be expressed by $V_t^p(\chi_t) = R_t^p(\chi_t|LFP_t^p = 0)$.

[70]$W_t^p(\chi_t^p) = \max_{c_t^p} \widetilde{u}_t^p(c_t^p(\chi_t^p), l_{t,LFP_t^p=1}^p(\chi_t^p)) + \eta\widetilde{u}_t^c(c_t^{c*}, l_t^{c*}) + \beta E_t\left[p_{t+1}^{hs_{t+1}\neq 3} V_{t+1}^p(\chi_{t+1})\right] + \beta(1 - p_{t+1}^{hs_{t+1}\neq 3})\theta_B E_t B(A_{t+1})$ where $p_{t+1}^{hs_{t+1}\neq 3} V_{t+1}^p(\chi_{t+1}) = \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}} V_{t+1}^p(\chi_{t+1})$ is shorthand expression to denote the expected future value conditional on health status transition, and the mortality rate $1 - \Sigma_{hs_{t+1}=0}^{hs_{t+1}=2} p_{t+1}^{hs_{t+1}}$ is simplified to $1 - p_{t+1}^{hs_{t+1}\neq 3}$ hereafter.

Euler equations: Euler equations can be derived through the combination of the standard first order conditions (FOCs) of optimal level of decision variables and envelope theorem (ET).

$\langle Child - household \rangle$

Following the assumption that child-household is not allowed to save, a one-unit increases in TR_t^c always causes the same amount decrease in their consumption ($\partial c_t^c / \partial TR_t^c = -1$). Given the child's problems expressed by the Bellman equation (1.38) or (1.39), FOC of child's decision on IVFT is expressed as follows:

$$\frac{\partial V_t^c(\chi_t)}{\partial TR_t^c} = -\frac{\partial \widetilde{u}_t^c}{\partial c_t^c} + \kappa \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} + \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}} \tag{1.40}$$

The interior solution of child's problems ($TR_t^c > 0$) needs to satisfy:

$$\frac{\partial \widetilde{u}_t^c}{\partial c_t^c} = \kappa \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} + \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}} \tag{1.41}$$

In the case of the internal solution, the child chooses optimal transfers which equalize the child's marginal utility and the sum of the parent's marginal utilities of consumption evaluated from the child's point of view and the discounted value of bequests given when the male-parent dies. However, if a child has just a limited amount of resources or has relatively rich parents, their optimal decision is characterized by $TR_t^c = 0$ (*i.e.* $\frac{\partial \widetilde{u}_t^c}{\partial c_t^c} > \kappa \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} + \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}}$).

$\langle Parents - household \rangle$

Given the parent's problems expressed by the Bellman equation (1.35), FOCs of the parents-household which male-member's age satisfies $t < T$ can be expressed as:

$$\frac{\partial V_t^p(\chi_t)}{\partial c_t^p} = \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} - \beta E_t p_{t+1}^{hs_{t+1} \neq 3} \left[\frac{\partial V_{t+1}^p(\chi_{t+1})}{\partial A_{t+1}} \right] - \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) \theta_B E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}}, \tag{1.42}$$

$$\frac{\partial V_t^p(\chi_t)}{\partial A_t} = \beta(1+r) E_t p_{t+1}^{hs_{t+1} \neq 3} \left[\frac{\partial V_{t+1}^p(\chi_{t+1})}{\partial A_{t+1}} \right] + \beta(1+r)(1 - p_{t+1}^{hs_{t+1} \neq 3}) \theta_B E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}}, \tag{1.43}$$

$$\frac{\partial V_t^p(\chi_t)}{\partial TR_t^p} = \eta \frac{\partial \widetilde{u}_t^c}{\partial c_t^c} - \beta E_t p_{t+1}^{hs_{t+1} \neq 3} \left[\frac{\partial V_{t+1}^p(\chi_{t+1})}{\partial A_{t+1}} \right] - \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) \theta_B E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}}, \tag{1.44}$$

where the expectation in equation (1.42)-(1.44) is taken over idiosyncratic components in the parent's out-of-pocket medical costs u_t and in the wage equation of the parent ξ_{t+1}^p and child ξ_{t+1}^c, respectively.

First, the interior solution of parents' problems ($A_{t+1} > 0$ & $TR_t^p > 0$) is given as follows:

$$\frac{\partial \widetilde{u}_t^p}{\partial c_t^p} = \beta(1+r)E_t p_{t+1}^{hs_{t+1}\neq 3}\left[\frac{\partial \widetilde{u}_{t+1}^p}{\partial c_{t+1}^p}\right] + \beta(1-p_{t+1}^{hs_{t+1}\neq 3})\theta_B E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}}, \quad (1.45)$$

$$\frac{\partial \widetilde{u}_t^p}{\partial c_t^p} = \eta \frac{\partial \widetilde{u}_t^c}{\partial c_t^c} \quad (1.46)$$

The optimum decision of parents is summarized by the system of two Euler equations (1.45)-(1.46). The combination of FOCs and ET yields the optimal levels of consumption between time t and $t+1$ (equation (1.45)), and the similar argument leads to the Euler equation that characterizes the optimal level of IVFT (equation (1.46)). Considering the fact that parents' decision on TR_t^p just has an effect on the amount of child's consumption under the assumption that male-child always works (if he receives a job offer), deriving TR_t^{p*} which satisfies equation (1.46) determines the amount of child's consumption.[71]

Given the functional form of per-period utility and the existence of the government transfer program, $c_t^{p*} > 0$ always holds. In regard to choosing TR_t^{p*}, there are three possible corner solutions. The first corner solution in IVFT is the binding credit condition (*i.e.* $E_t A_{t+1} = 0$). In this case, equation (1.46) still yields the optimal level of transfers. Another corner solution in IVFT is given by $TR_t^p = 0$. Now, the relation in equation (1.46) no longer holds (however, the optimal condition of the other controls still holds by equations (1.45)). In order to satisfy the complementary slackness condition, $\frac{\partial \widetilde{u}_t^p}{\partial c_t^p} > \eta \frac{\partial \widetilde{u}_t^c}{\partial c_t^c}$ needs to hold, and this implies that the additional utility gains of the parents caused by the provision of one-unit of resource to their child-household are lower than the utility loss caused by the reduction of their own consumption. The final corner solution in financial transfers is that both of the first and second corner solution conditions occur at the same time. This leads to the result of hand-to-mouth, and equations (1.45) and (1.46) do not hold. In this case, the level of parents' consumption is determined by their currently available resources.

1.5 Identification and Estimation Strategy

The model period begins from the age of 55 (model age 0), and death occurs at the end of age 90 with the probability of one ($age_{it}^p \in [55, 90]$). I assume that a period

[71] The likelihood and level of parental transfers are determined by equating the marginal benefit (MB) and cost (MC) to the parents along the equilibrium path. The MC and MB of downstream transfers are marginal utility (MU) from parents-households' current period consumption and MU from child-household scaled by η_k.

in the model corresponds to three years, so each male-parent has a lifecycle of up to twelve model periods. In order to achieve the goal, the required sets of parameters are divided into three categories. First, I take some parameters from outside. For the purpose of compatibility with other empirical research, the discount factor β is set to 0.96, and time endowment $\overline{L}$ is equal to 4,500 hours. The real annualized post-tax interest rate r is considered to have a value of 4.0%.[72] Also, considering the maximum amount of BOAPS support for a two-person household (1.9 million KRW in June 2014), the amount of yearly government transfer for elderly people is set to 1.8 million KRW $\hat{y}_{min} = 1,800,000$ (approximately U.S. \$1,600). The second set of parameters is estimated external to the model. The coefficients on the LFP probabilities and non-labour income of female-family member in each household, medical costs, and health transition matrix are included in this category and estimated directly from data. Lastly, based on the first two sets of parameters, the set of earnings β^P & β^C, exogenous job-separation Λ_s, and -arrival 1-Λ_{un} rate, the set of unobserved type assignment probabilities λ^1 & λ^3, and preference parameters θ is determined through matching moment conditions.

1.5.1 Identification of Model Parameters

Except for altruism factors, the identification of other preference parameters is standard and depends mainly on male-household members' LFP and savings choice. I pin down relative risk aversion σ, bequest shifter θ_B, and bequest curvature K mainly by matching the mean wealth of parents aged 55-81 because it is important that the model generates the right amount around the time that elderly people decide to leave the labour force. The parameters of the fixed cost of work $\gamma_P, \gamma_{Fair}, \gamma_{Bad}$ and consumption weight α are identified by targeting the LFP rate of male-parent. The mean LFP rate of male-child is used to pin down exogenous job separation rate Λ_s and arrival rate of job $1 - \Lambda_{un}$.

The altruism η_k, κ_k, family type assignment $\lambda^1, \&\lambda^3$, and amount of unemployment insurance benefits b parameters are mainly identified by matching the average proportion of parents- and child-household supplying IVFT toward the other household in the family because the incidence of IVFT in this model is caused by altruism toward the other party in the same family. For example, as parents become more altruistic toward their child, they are more likely to sacrifice their own leisure or asset holdings to increase child's consumption today. Thus, more parents-households become a donor of IVFT. Also, as the vector of covariates X_i

[72] The average long-term interest rate between 2006 and 2016 in Korea was 4.0% (OECD Statistics: Key Short-Term Economic Indicators).

includes educational attainment of both male-parent and -child, these reflect each household's economic ability closely related with the provision as well as the size of IVFT. Also, the existence of siblings living together with parents $I_{\{Sib_i \geq 1\}}$ may be associated with the probability that a family belongs to a certain type and play a role as an additional exclusion restriction.[73]

The earning process parameters for male-parent and -child is derived using simulated workers. The OLS or fixed-effect estimators are identified directly from observed wage profiles from data that only include observations for workers, so potential wage rates of non-participants cannot be used to estimate parameters. In particular, as the elderly leave the labour force with age, estimation methods using actual wage profiles cannot properly control the selection bias. For example, if an individual who experiences sudden negative productivity shock may be more likely to choose retirement, then the estimated profiles which only use people in the labour force overestimate the wage rate. On the contrary, if people who have received continuous positive wage shocks can accumulate sufficient assets and leave the labour force earlier to enjoy more leisure, then estimated profiles would be under-stated.

Likewise, the observed wage growth rate can be either under- or over-estimate actual wage profile, so a decomposition analysis that does not consider the sample selection issue properly can be potentially biased if the estimation is performed on the data collected from people in the labour force. Therefore, in order to control the selection bias, β^P & β^C are estimated by the structural model. If the bias in the actual wage profile occurs to the simulated profiles in the same manner, wage profiles for all simulated individuals can be used to correct selection bias. To do this, the average and standard deviation of male-parents' and -children's yearly after-tax income in the data are used as moment conditions.

1.5.2 Solution Methodology and Initial Conditions

In order to estimate the vector of unknown preference, earnings and type assignment probability parameters, the method of simulated moments (MSM) strategy is employed. As moment conditions, I use the LFP rate of male-parent and -child, net wealth, the proportion of each household providing downstream and upstream net-transfers and average as well as the standard deviation of each male-household

[73] 40.3% of parents-household whose male-member is assigned to low education group have children who are living together, however, around 12%p more parents in high-education group co-reside with one or more children.

member's yearly earnings. In total, 80-moment conditions are used.[74] These moment conditions are calculated from the final sample (these moment conditions are called 'empirical moments' henceforth.).

The parameters are estimated by the following procedure: (1) The solution of the model in this study consists of policy functions for consumption, the LFP and both households' IVFT choices. As the model cannot be solved analytically, it must be solved numerically from the last to the first model period iteratively at each age group, (2) Initial conditions are drawn from the empirical joint distribution for 20,000 simulated families, and the Gauss-Hermite quadrature method is used to discretize the state space of out-of-pocket medical cost shocks and each male-household member's unexpected wage shocks. These discretized *iid* shocks are fed into the model, (3) Based on the model solution and initial conditions, simulated profiles corresponding to the data-moments are derived, and (4) The parameters are chosen to minimize the distance between empirical moments and their simulated counterparts as closely as possible.

In particular, the initial conditions are drawn from the empirical joint distribution of net-asset holdings and national pension separately for the low- and high-education groups. With regard to the household's observed and unobserved characteristics, male-child's education level, and the existence of siblings living together with parents are randomly drawn conditional on male-parent's educational attainment. The discretization used for the age difference between the male-parent and -child Δ_i is 25, 28, and 31, and the proportion of each age-gap is set to be 25%, 50%, and 25%, respectively. Also, there is no difference between high- and low-educated group in the relative share of Δ_i.[75] Once the preference, type assignment probabilities and earnings parameters are estimated, I then simulate the model family-by-family and conduct counterfactual analysis.

1.6 Parameter Estimates and Model Fits

To quantify the relation between family resource sharing and elderly people's life-cycle choice, I structurally estimated the model from KLIPS. Considering computational burden, relatively less crucial parameters such as health transition

[74] (1) 8-mean of male-parents' LFP rate for age group 55-78, (2) 11-mean of male-child's LFP rate when their male-parent's age is between 55-87, (3) 9-mean of net asset accumulation for age group 55-81, (4) 9-share of each household which make net-transfers for age group 55-81, (5) 8-average and 8-standard deviation of each parents-household's yearly after-tax income for age group 55-78, (6) 9-average and 9-standard deviation of each child-household's yearly after-tax income when their male-parent's age is between 55-81.

[75] The mean and standard deviation of the age-gap for the low (high) education group are 28.9 (28.6) and 4.42 (4.37), respectively.

probabilities, medical costs, non-labour income are estimated outside of the model.[76] As fixing these outside-model parameters, the model is numerically solved, and the remaining parameters are structurally estimated using a set of moment conditions.

1.6.1 Preference, Type-Assignment and Earnings

The preference and type-assignment parameters are presented in the first panel of table 1.5. There is noticeable heterogeneity in unobserved family types. The estimated values of parents-households' type-specific attribute η_k which parents in type-k place weight on their child-household's utility are 0.6658 for type-1, 0.6229 for type-2, and 0.5103 for type-3, respectively.[77] Comparing it with their own utilities, the result implies that parents-households place more than half of the value on child-households' utilities. The estimated extent of unobserved type-dependent child's altruism weights κ_k (from type-1 to -3) are 0.0114, 0.0152, and 0.0236 which are comparable with 0.011-0.025 in **?** and 0.012 in **?**.[78] Also, the gap between η_k and κ_k corresponds to **?**. The estimated proportion of families assigned to unobserved heterogeneity type-1, -2, and -3 are 36.7%, 8.3%, and 55.0%, respectively.[79]

Turning next to the estimated relative risk aversion (RRA) for consumption is 4.7045 ($\sigma = 6.7788$), and the estimated value of preference on consumption relative to leisure is 0.6411.[80] The estimate of yearly unemployment benefit b is 21.69 million KRW which over-estimates the actual amount of UI payouts.[81] However, considering the fact that the mean duration of unemployment is 3.0 month, and the proportion of unemployed whose unemployment duration is over a year was just 0.9% among the total unemployed in 2016, the difference would be acceptable. The fixed cost of labour force participation γ_P is 459 hours per year. The estimates of

[76]The explanation of such parameters is summarized in Appendix A.3.

[77]Comparing it with families in type-2 μ_2, parents in type-1 (type-3) put higher (less) weight on their child's utility. Thus, if all else is equal, type-1 (type-3) parents are more (less) likely to provide downstream-IVFT than type-2 parents. Also, it is impossible to directly compare the estimated η_k in this study with other studies using data from different countries. There is a wide difference in the estimated value of the parameter in the literature, and it ranges from 0.04 in **?** to 0.63 in **?**. In recent studies, **?**, **?**, and **?** show a value of 0.27, 0.69, and 0.49, respectively. Relative to previous studies, the estimated η_k in this study is neither exceptionally high nor low.

[78]**?** uses the HRS and imposes the assumption that children cannot save. The estimated value of a child's altruism is 0.011 for male and 0.025 for female offspring.

[79]Comparing it with individuals belong to type-2 unobserved heterogeneity, a family consisting of high-educated parent, low-educated child, and having no siblings co-residing with parents is more likely to be assigned to type-1 family μ_1 whose parents have relatively high altruism toward their child, and child-household places relatively low weight on parents-household's utility. A family whose male-parent and -child is classified as a group L and H, and has siblings who co-reside with parents tends to be assigned to μ_3 unobserved heterogeneity group.

[80]The RRA for consumption can be approximated as $-\frac{(\partial^2 U/\partial C^2)\cdot C}{\partial U/\partial C} = 1 - \alpha(1-\sigma)$.

[81]A single unemployed person in 2018 is expected to receive 7.72 million KRW on average.

time cost associated with 'Fair' γ_{Fair} and 'Bad' γ_{Bad} health state are 659 and 977 hours per year, respectively. Finally, the estimated bequest shifter θ_B is 0.000065, and the curvature K is 20.51 million KRW.

The first panel of table 1.6 provides earnings process parameters estimated for the male-parent and -child. As expected, elderly- and young-male workers' earnings show opposite trends with age. The earnings of the elderly decrease with age, while young people's earnings increase. If a male-parent is categorized as the high educational attainment group, his earnings are 44.4% higher than those of the low-educated group. Although a male-child in the high-education group also earns more (21.9%), earnings premium from education is reduced as more young people receive higher-education. The parameters on health status $I_{\{hs_{it}=\cdot\}}$ show that relatively poor health status has a huge negative effect on productivity. Having 'Fair' and 'Bad' health are associated with 17.5% and 37.4% reduction in yearly after-tax earnings.

1.6.2 Model Fit

This subsection evaluates the model's ability to generate family members' major choices over the life-cycle. Figure 1.6-1.8 show the overall fitness of the model relative to the empirical moments. The simulated profiles for the male-parent's age 55-84 are the path of average changes in this paper. In general, it does a good performance in generating family members' patterns of life-cycle choices observed in the latter part of their life. The model closely replicates the unconditional mean of labour supply, wage process, savings and health status transitions.[82] In particular, the simulated likelihood of individuals providing IVFT are fairly close to the actual data, however, the model overpredicts the average amount of upstream transfers.

Panel (a)-(f) of figure 1.6 compare the simulated LFP and wage profiles of male-parent and -child with those of empirical counterparties by male-parent's age. It is particularly important to closely match the labour supply, wage and savings profiles because the aim of this study is to evaluate the effect of within-family two-way altruism on elderly people's work and retirement choice. Although the model slightly overpredicts the LFP rate of elderly workers (panel (a)), it closely replicates the gradual transition from work to retirement with age. Comparing it with other western countries which show a sudden drop in the LFP rate around the time at which the earliest or full national pension application is eligible, the weak social insurance program in Korea causes its people to rely more on their earnings. Between the age-group 55-78, the model overstates elderly workers' actual

[82] All the simulated profiles are conditional on the survivor of male-parents.

labour supply choice by 0.9% (0.6%p) on average (data: 55.6% & model: 56.2%). The over-prediction for older worker labour supply is partly caused by the under-prediction of their earnings (panel(c)). Between the age of 58-69, it underpredicts elderly people's earned income by 6.5% (data: 25.9 & model: 24.2 million KRW).

As this study does not model child-household's labour force choice, the job offer arrival rate and job destruction rate completely govern their labour supply. The model fits well in the male-child's LFP rate (panel (b)) and their earned-income (panel (e)). Panel (g) and (h) of figure 1.6 and figure 1.7 display the amount of parents-household's net-asset holdings, medical expenditures and changes in health status, respectively. The model approximates very well the changes described in the figures. In particular, it appropriately replicates the dynamics of asset accumulation; asset holdings increase until a certain age and then decrease gradually. However, the model understates the evolution of actual saving choice by 11.0% on average (data 67.0 & model: 59.7 million KRW).

The model is able to predict the size as well as the timing of bidirectional IVFT which are displayed in figure 1.8 and table 1.7. The figure shows the unconditional average amount of downstream and upstream transfer provision and the proportion of households, which provide transfers.[83] The model captures the patterns of intra-family financial transfer provision quite closely. Panel (a) of the figure shows that on average, 16.6% of simulated parents make financial transfers that are equal to the share in the empirical counterpart. As the model closely fits the likelihood of parents' IVFT provision, it also adequately generates the amount of downward transfer provision. Panel (b) compares the average actual amount of downstream transfers with the model predicted counterpart. On average, the model implied amount of yearly transfer for age-group 55-84 is 0.47 million KRW which overstate the empirical amount of downstream transfers by 12.1% (0.42 million KRW).

The model implied likelihood and unconditional amount of upstream transfer provision are displayed in panel (c)-(d). The model closely replicates child-households' support over the life-cycle and well captures the empirical regularity; more children provide more financial support for elderly households as their parents grow older. The model implied an average share of child-households who make upstream transfers is 63.7% which appropriately fits the pattern observed in the data (68.6%). On average, the actual amount of transfers that child-households send to their parents is 2.56 million, however, the model over-predicts the amount by 0.45 million KRW.

Table 1.7 reports each household's changes in the decision between provision and non-provision of IVFT generated by the model and ones observed in the actual data.

[83]The unconditional mean of net-transfer amount: $\overline{TR}_t^j = \frac{\Sigma_{i=1}^{N_t} TR_{it}^j}{N_t}$, where N_t denotes the number of elderly-male survivors at the beginning of each period t.

Neither transition of downstream nor upstream transfer incidence are not used as the target of moment conditions, however, the model relatively well captures the patterns of both households' choice. Although the model overpredicts the share of the child who does not provide IVFT at both times t and $t+1$, the model precisely replicates parents' transfer provision as well as non-provision choices at time t and $t+1$ and relatively well predicts the child's incidence of IVFT provision choice. These results can be partly interpreted as the evidence that the model assumptions, such as simultaneous move non-cooperative game and the mode of competition within a family, are appropriate to capture the process of choosing IVFT provision.

1.7 Counterfactual Analysis

This section revisits the structural model and its parameter estimates to perform counterfactual experiments. The model specification explained in section 1.4 and predicted life-cycle profiles provided in section 1.6 are regarded as the 'Baseline'. The simulated profiles under the baseline serve as the basis and are compared to the corresponding profiles of counterfactual regimes. The next subsection analyses the implications of two sets of counterfactual policies for elderly people's labour force choice, security in retirement and strategic behaviour between family members. After then, the following two subsections evaluate how ignoring bidirectional transfers have effects on the parameter estimates, model prediction and policy effects.

1.7.1 Policy Counterfactuals

Determining the impact of increasing public transfer and state pension on the incidence as well as the amount of private transfer choices is an important issue for researchers and policymakers. Although previous studies provide a rough prediction of policy impacts on some important factors such as the LFP, asset accumulation and intra-family resources allocation, most of them have focused on one or at most few of them and rely on reduced-form approaches. However, as all these variables interact with each other rather than acting independently, the welfare evaluation of introducing policies can be misleading if dynamic interaction is ignored.

If the expansion of public transfers or state pension for elderly people induces a great magnitude of reduction in private transfers, precautionary savings or labour supply rather than increase in their consumption, the government's anti-elderly poverty programmes would just have limited effects. Put somewhat differently, an increase in retirement income can be just offset by adverse effects such as the decrease in the amount of intra-family resource allocation or early retirement. In such a case, it would be better for the government to focus more on different policy alternatives such as improving employment opportunities for the elderly or concentrating the support for people who have disabilities rather than increasing general elderly support.

In this subsection, I evaluate the dynamics of bidirectional likelihood as well as the amount of IVFT, asset accumulation and labour force choice under the two different counterfactual regimes: an expansion of the maximum amount of Basic Pension Scheme (BPS) and an increase in average National Pension Scheme (NPS) benefits. The changes in BPS and NPS benefits are known (*i.e* common knowledge) for all family members at the beginning of the model period. These policy analyses aim to assess the effectiveness of expanding BPS and NPS benefits on changes in elderly people's life-cycle choices.

Reinforcement of Old Age Income Security through BPS: BPS is a sort of guaranteed minimum income, which the government pays to its elderly citizens.[84] In order to combat elderly poverty, the Korea government has raised the maximum yearly amount of BPS benefit payments for a two-person household with lower 20% of income from 1.90 to 5.76 million KRW since April 2019.[85] Thus, I examine the effect of higher yearly BPS benefits $\hat{y}_{min}$ from 1.80 to 5.50 million KRW.[86] Also, considering the fact that elderly people whose age is 65 or older are subject to the benefit, the expansion of BPS begin to be fully applied from the model period-5 (age 67-69), and the guaranteed minimum level of resources for elderly people aged 64-66 is 4.30 million KRW.[87] This counterfactual policy is referred to by 'New-BPS' henceforth.

In the literature, the estimated crowding-out effects of public transfers have a wide range of values. One dollar increase in pension income is associated with the reduction in the amount of transfers from children by 20-90 cents (**?**). For example, **?** shows the effect of pension benefit expansion on the size of remittance payments given to elderly people. Following his estimation results, a one-dollar increase

[84] The program is similar to Supplemental Security Income in the U.S.

[85] The maximum monthly amount of BPS support for a two-person household with lower 20% (20%-70%) of income is 480,000 (406,000) KRW. The amount of BPS benefits is derived by subtracting assessed income and converted property income from maximum BPS benefits.

[86] 5.76 million KRW is deflated by the yearly CPI of the year 2015 ($\hat{y}_{min}$= $5.50 \approx 5.76 \cdot \frac{100.00}{104.45}$). The receipt of each household's BPS amount follows the transfer provision rule expressed in equation (1.23).

[87] As the eligible age of BPS is 65 years and one period in the model corresponds to three years, the maximum amount of resources that government provides to secure a minimum level of resources is 1.8 million KRW at age 64 and 5.5 million KRW from the age 65. Thus, the maximum amount of government transfers in model period-4 (64-66) is set as 4.3 million KRW ($4.3 \approx \frac{1.8+5.5+5.5}{3}$).

in pension income is associated with the reduction in the amount of upstream transfers by 25-30 cents. **?** and **?** find that the estimated crowding-out effect of private transfers in response to the social assistance program is 25% and 88%, respectively.[88] However, most of these studies rely on static reduced-form analysis and focus on the relation between the changes in public support and one or just a few of them. Thus, such models may have difficulties in properly capturing the dynamic interaction between government supports and individuals' choices such as labour supply, savings and IVFT.

The second column of the first panel in table 1.8 shows the effect of maximum BPS benefit expansion on several selected variables under the model with IVFT. The policy counterfactual suggests three important points. First, the expansion of maximum BPS benefits causes sharp changes in the number of beneficiaries and amount of average benefit receipt. As the government increases the maximum amount of support, more older people meet the eligibility requirements. Relative to the baseline, the average proportion of BPS beneficiaries and beneficiaries' benefit level for the age-group 64-84 increase by 11.3%p (from 57.0% to 68.3%) and 2.0 million KRW (from 1.55 to 3.54 million KRW), respectively.[89] As a result, a one-unit rise in the maximum BPS benefits increases the average yearly amount of benefit payments each household can receive between ages 64-90 by 0.46 unit.[90].

The second point is that the considerable effect of the rise in the guaranteed income is crowded-out by the decrease in pre-existing private transfers. A unit increase in mean-tested benefit is associated with more than a one-third unit reduction in the amount of family transfers. Although downstream and upstream transfers move in the opposite direction, the absolute amount of upstream IVFT reduction is greater than the rise in the level of downstream support. As a result, the intervention crowds out the net- as well as gross-intrafamily resource allocations. Under the New-BPS, survivors aged 55-90 additionally receive 1.22 million KRW yearly benefits from the government on average, however, yearly upstream transfers decrease by 0.63, and yearly downstream transfers increase by 0.19 million KRW. As a result, when the government increases the BPS benefits by one-unit, just 0.33 units of government supports are used for elderly people, and intrafamily resource

[88] In addition, **?** study about the effect of introducing the Basic Old-Age Pension Scheme which is an elderly support program and has been replaced by BPS since July 2014. They show that a one-dollar increase in pension income is associated with the reduction in the amount of upstream transfers by 98.4 cents.

[89] As of December 2019 and November 2020, 66.3% and 66.5% of elderly people aged 65 or older received BPS, respectively.

[90] 3.06 times rise in the maximum amount of BPS benefits causes 2.70 times (Baseline: 0.99M / New-BPS: 2.68M KRW) increase in unconditional average BPS benefits ($= \frac{1}{9}\Sigma_{t=4}^{12}\frac{1}{N_t}\Sigma_i TR_{it}^{G}$). Thus, $0.46 = \frac{2.68-0.99}{5.50-1.80}$.

allocation through IVFT decreases by 0.36 units.[91]

Finally, the overall welfare gain of BPS benefit expansion assessed by the value of consumption compensation is equivalent to a 0.003% increase in consumption overall.[92] However, due to the increase in downstream support and savings and the decrease in upstream transfers, there is just a limited difference between the simulated average consumption under the New-BPS and baseline.[93] Also, the policy weakens elderly people's labour force attachment (LFP rate under baseline: 56.2% / New-BPS: 55.7% on average), however, it has a limited effect on elderly people's work and retirement choice. This is because although the amount of government supports is increased greatly under the New-BPS, it is still below 30% of the minimum living cost in Korea.[94] Thus, the policy effect is mainly reflected in the form of a decrease in family insurance and an increase in consumption of child-households rather than a great improvement in the well-being of the elderly.

In conclusion, the results of the government support expansion experiment illustrate that the effectiveness of transfer programs could be hugely hampered in countries where intergenerational transfers are widely observed. Rather than increasing elderly people's consumption, the expansion of non-contributory benefit payment mainly results in crowding-out private insurance and (unintended) redistribution of resources from government to child's household.

Reinforcement of old age income security through NPS: The second counterfactual policy analysis examines the effect of offering more generous state pension benefits. I consider an 11%p increase in the proportion of people eligible for public pension (from 60.9% to 71.6%) and a 15% increase in average pension benefits (from 5.48 to 6.29 million KRW) at the same time.[95,96] This experiment may not

[91]Total government yearly average support $\overline{TR}^G$ is derived by $\overline{TR}^G = \frac{1}{\overline{N}\times 12}\Sigma_{t=1}^{12}\Sigma_{i=1}^{N} TR_{it}^G$, where t is for model period, i is for individual, and $\overline{N}$ is for the average number of living parents between the age 55 and 90. $0.33 = 1 - \frac{187{,}000+629{,}000}{1{,}218{,}000}$ and $0.36 = \left|\frac{187{,}000-629{,}000}{1{,}218{,}000}\right|$.

[92]Following **?**, the value of consumption compensation can be derived by eq which is the solution $EV_{base} = \Sigma_{t=1}^{12}\frac{1}{N_t}\Sigma_{i=1}^{N_t}\beta^{t-1}U_{it}^p(k)\times(1+eq)^{\alpha(1-\sigma)} = (1+eq)^{\alpha(1-\sigma)}\times EV_{New-BPS}$. The equation can be solved for eq and yields $eq = \left(\frac{EV_{base}}{EV_{New-BPS}}\right)^{1/\alpha(1-\sigma)} - 1$

[93]The level of yearly average consumption under the baseline and New-BPS are 29.7 and 30.3 million KRW, respectively.

[94]In 2019, the minimum monthly cost of living for a two-person household is 1,795,188 KRW which is 3.74 times greater than the maximum BPS benefit.

[95]It is assumed that all eligible individuals in the model begin to draw the benefit from age 61.

[96]As this study assumes that the initial condition of NPS benefits is drawn from the empirical joint distribution, and the amount as well as the right to claim the pension are given exogenously for reducing computational burdens, the counterfactual scheme is modelled as a 50% shift of the mean national pension-income distribution to the right. This experiment only raises the mean of national pension payments by 50%, and the covariance matrix of initial joint distribution has

be absurd because if the government keeps the current pension rule, the number of pensioners and its amount under the current state pension system will automatically increase as the scheme becomes more matured.[97] The counterfactual regime in this subsection is referred to by 'New-NPS', and it examines the effect of the rise in the contribution year of NPS under the current system and the response of family members.

Several interesting results emerge from this experiment. The third column of the first panel in table 1.8 summarizes the effect of changes in NPS benefits on several selected variables. First, there is weak substitutability between pension benefits and desirable level of asset holdings, and thus the rise in retirement income does not discourage elderly people's asset accumulation incentives. As individuals have more retirement income, the forward-looking elderly have an incentive to increase consumption before they begin to draw the national pension for smoothing consumption. However, due to the uncertainty on survivor and health cost risks and bequest motive, elderly people do not additionally reduce savings much to consume more. The average yearly consumption is 1.1% (312,000KRW) higher than that of the baseline, however, the increase in national pension does not encourage people to reduce precautionary savings much (baseline: 59.66 / New-NPS: 59.38 million KRW).

Second, the rise in contributory old-age pension benefit has a limited negative effect on retirement behaviour as strategic behaviour between parents and children is considered. The average effect of the increase in pension income on the elderly workers' labour supply is small in magnitude and negative (baseline: 56.2% & New-NPS: 55.4%). However, there are relatively huge differences when divided by age-groups. The inter-temporal substitution effect associated with the rise in retirement income causes individuals to work more before the national pension age and less when eligible for the NPS benefits. Because rational individuals are willing to substitute their labour supply across periods, they work more at the period when they can be rewarded more and leave the labour force earlier as they have more retirement income from the pension. Comparing it with the baseline, the average LFP rate is increased by 0.1%p between the age of 55-60 and decreased by 1.0%p for the age-group 61-78.

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remained the same. Also, due to the correlation between the initial assets and national pension benefits, the mean of asset holdings is also adjusted to meet the initial asset holdings of the data.

[97] When the NPS was first introduced in 1988, only a fraction of employees in the private sector were covered. Since 1999, the coverage was extended to all the paid-workers and self-employed. Thus, between 2010 and 2018, the average contribution period has increased from 9.8 to 12.1 years and is expected to rise to 20.0 years by 2040 (National Pension Research Institute, 2013). However, if the Korea government does not change the current system, the NPS fund will be fully depleted by 2060 (Ministry of Health and Welfare, 2014).

The third is that a large amount of intrafamily transfers could partly stem from the high elderly poverty rate, and thus the amount of financial transfers between family members would gradually decrease with the maturity of NPS and rise in the number of people covered by the public pension. As parents-households have more economic capacity (i,e, increase in NPS benefits), the necessity of supporting parents decreases. Because the changes in NPS benefits have the opposite effect on the incentives of downstream and upstream transfers, the overall effects on pre-existing family supports would be priori undetermined, and thus the direction will be determined by the relative size of coefficients involved. Row 3-6 of column 3 of the first panel show that comparing it with the baseline, both the fraction of parents making downstream IVFT, and level of support increase when elderly people have more retirement income. However, the fraction as well as the level of support from child-households decrease.[98] As a result, the proportion of family making IVFT increases by 0.8%p (from 80.4% to 81.2%), however, the level of support decreases by 2.4% (from 3.48 to 3.39 million KRW) under the counterfactual regime.[99] These imply that a one-unit increase in contributory benefits causes a 0.26 unit decrease and a 0.04 unit increase in the amount of upstream and downstream transfers on average, respectively. Also, as more older workers are eligible for the national pension, the proportion of elderly-households who rely on the public transfer programme and its average payments decrease by 7.6%p and 3.5%, respectively.

1.7.2 Dis-allowance of Inter-Vivos Financial Transfer

The baseline model described in section 1.4 shows that two-way altruism leads to bidirectional IVFT and causes family members to engage in strategic interaction. Since transfer decision is not made in a void, one family member's transfer choice affects not only the decisions of that member but also the other members' optimal choices. In order to answer the question, how important is the sharing resources within families to understand elderly people's labour supply and savings choices, this subsection compares the parameter estimates and simulated profiles under the baseline with those under the regime which does not allow all kinds of within-family resources allocation except for bequest. The result from this counterfactual experiment demonstrates the importance of inter-generational resource sharing

[98]Under the New-NPS, the proportion of parents making IVFT is 2.1%p higher, and the unconditional average yearly parental transfer increases by 12% (54,000KRW). However, the proportion of child making IVFT is 1.3%p lower, and the unconditional average yearly upstream transfer decreases by 5% (138,000KRW).

[99]The money values denote the sum of the average downstream and upstream IVFT incidence and amounts.

which has not been much considered by previous works on this type of model. Also, in the next subsection, the model excluding IVFT is used to show the importance of the family insurance channel when examining policy effects.

In this subsection, transfers in both directions are not allowed (*i.e.* $TR^p_{it} = TR^c_{it} = 0$ for all i and t), and thus elderly households now make the best possible choices under the constraints that they directly face. This implies that the model structure in this subsection corresponds to the typical life-cycle model, and each household behaves in a self-interested fashion. Thus, I assume $\eta_k = \kappa_k = 0$ for all k, and this simpler structure model is referred to by No-IVFT henceforth.[100] As the exclusion of bidirectional family transfers would result in significant economic as well as behavioural changes, related preference parameters also need to be newly estimated for capturing such changes. Also, individuals' self-selection could be reflected differently in earnings parameters. Thus, the set of preference parameters θ' and earning process $\beta^{P'}$ is estimated by repeating procedure 1.5.2 in the context of a model excluding IVFT.

$$\theta' = \{\sigma', \alpha', \gamma'_P, \gamma'_{Fair}, \gamma'_{Bad}, K', \theta'_B\}, \quad \beta^{P'} = \left\{\beta^{p'}_0, \beta^{p'}_{1'}, \beta^{p'}_2, \beta^{p'}_3, \beta^{p'}_4, \beta^{p'}_5, \sigma^2_{\xi^{p'}}\right\} \tag{1.47}$$

Column 3 and 4 of table 1.5 and 1.6 show the list of parameter estimates and their standard errors under the No-IVFT. The coefficient of RRA for consumption is 3.7203 which is lower than that of the baseline. A smaller estimate of the coefficient of RRA for consumption implies that individuals save less given the level of assets and uncertainty. However, the relatively small estimate does not imply that elderly people under the No-IVFT are less risk-averse because the uncertainty that child households face (income and labour force status) does not play a role in parents' choices. The estimates of time cost associated with participation and fair-health state are larger than those of the baseline. Also, as expected, the exclusion of intrafamily strategic behaviour affects the patterns of elderly people's selection between work and retirement, and these changes are reflected in $\beta^{P'}$.

Column 1 of the second panel in table 1.8 shows the selected average simulated profiles under the No-IVFT regime, and figure 1.9 compares the simulated profiles under the No-IVFT with those from the baseline and actual data. The model without strategic interaction also reasonably accounts for elderly people's patterns of life-cycle choices. Panel (a) shows the LFP profiles. Although the alternative specification also results in proper replication of elderly workers' labour supply choice, it understates the LFP choice between the age of 55-63 and overpredicts

[100]Parents still value bequests of assets when they die.

thereafter.[101] Thus, simulated individuals in the No-IVFT leave the labour force more gradually than actual people in the data and simulated individuals under the baseline. The gradual labour force exit under the No-IVFT is partly caused by the fact that the elderly need to rely more on their earnings if there is no financial support from their child. Such a change is also reflected in the simulated earnings and asset-holdings profiles. Panel (b) displays that in order to capture the labour force choice of elderly workers who cannot rely on family members, the productivity under the No-IVFT needs to decrease more rapidly than that of the baseline. Also, due to insufficient pension benefits and public spending for guaranteeing security in retirement, simulated workers under the No-IVFT are less willing to use their precautionary savings for consumption (panel (c)), so asset holdings decrease more gradually.

1.7.3 Policy Effect Comparison between Full-Model and No-IVFT

This subsection compares the effects of the increase in BPS and NPS benefit payments on elderly households' choices under the full-model (section 1.7.1) to those under the No-IVFT (section 1.7.2). Through these comparisons, I illustrate that the effects of government welfare policies can be misleading if the two-way intra-family insurance channel is not considered adequately and demonstrate the need for understanding policy effects based on the unified dynamic framework.

Column 2 of the second panel in table 1.8 provides the average life-cycle profiles of selected variables under the No-IVFT & New-BPS. Although the signs of policy effect on main variables correspond to the full-model (New-BPS with IVFT) except for net-asset accumulation, the counterfactual regime under the restricted model structure significantly overstates the magnitude of the changes. Comparing it with the IVFT & New-BPS, the elderly under the No-IVFT & New-BPS are more likely to rely on government supports, save less and consume more. The most obvious indication of bias can be found in the relation between policy intervention and labour force choice. While simulated individuals under the model excluding IVFT significantly decrease labour supply, the model with IVFT predicts just a slight drop in the LFP rate of elderly people as the government increases maximum BPS benefits. However, the prediction under the model with IVFT is strongly supported by actual data.[102] Therefore, policymakers need to consider the role of IVFT as

[101] In total, the average LFP rate between the age 55-78 under the NO-IVFT overstates that of the actual data by 2.7%p.

[102] Males' yearly employment rate aged 55 or higher: 2018 62.0% → 2019 61.7% → 2020 61.6% (the government has raised BPS benefits since April 2019, source: KOSIS).

well as potential responses of extended family, and the effects of public transfer policies can rely on the presence of additional support from their own children or any other parties.

Column 3 of the second panel in table 1.8 shows the average life-cycle profiles under the No-IVFT & New-NPS specification. The direction of change in selected variables caused by reinforcement of retirement income generally corresponds to the model with IVFT (IVFT & New-NPS). However, the counterfactual regime under the restricted model structure hugely overstates the magnitude of changes in general. Comparing it with the percentage change observed under the New-NPS with IVFT, the elderly under the No-IVFT & New-NPS work less than those under the No-IVFT.[103] Also, as elderly people under No-IVFT cannot rely on family insurance provided by child-household, they save a higher proportion of retirement income. Under the No-IVFT & New-NPS, the level of asset-holdings increases by 2.3% relative to the No-IVFT, despite the drop in LFP. These results illustrate that the policy effect would vary whether elderly people have access to family insurance or not, so proper consideration on intrafamily interaction is required when reforming the public pension scheme.

1.8 Conclusion

This paper contributes both to the study of family members' life-cycle choice patterns and the analysis of the relationship between strengthening security in retirement and bidirectional IVFT. The innovation of this study is to synthesize models from two series of literature that have evolved separately from one another in various respects: one on elderly people's work and retirement choice and the other on private bidirectional insurance provided by extended family. I derive the MPE of a family which is consisted of two altruistic decision-makers, parents- and child-household pairs, who play a dynamic simultaneous move intergenerational finite horizon game without cooperation. Although the model simplifies many factors which have effects on family members' life-cycle choices, it adequately reproduces elderly workers' labour supply, asset holdings and health status transitions. In particular, it is able to closely reproduce the incidence of bidirectional financial transfers between parents- and child-households.

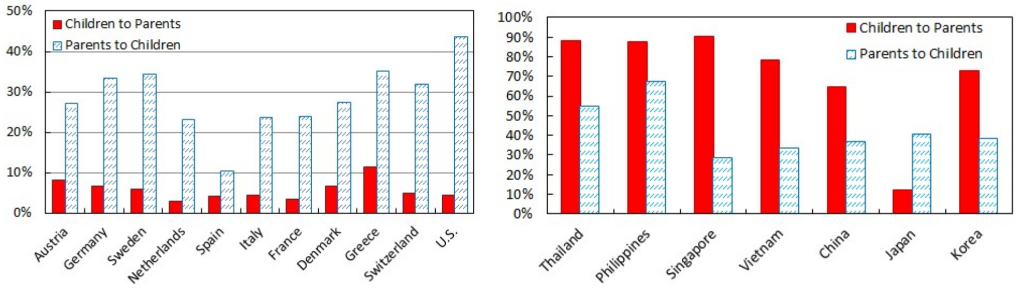
Recently, in response to the rapid ageing of the population, many governments in the world has introduced a diverse kind of programmes, and various questions

[103] Comparing it with the baseline model, the average LFP rate decreases by 0.8%p under the New-NPS with IVFT. However, the average LFP rate under No-IVFT & New-NPS is 55.6% which is 2.7%p lower than the rate under the No-IVFT (58.3%).

are being raised with respect to the direct or indirect effect of these policies on individuals' life-cycle choices. Two sets of policy counterfactuals experimented in this study clearly hit the answer to these questions and evaluate the effectiveness of different forms of strengthening security in retirement on elderly people's labour supply, asset holdings and intrafamily resource allocations. I find that the effectiveness of government transfers for elderly people could be hugely dampened in the countries where intergenerational family insurance is widely observed, and a one-unit increase in mean-tested benefit causes a 0.36 unit reduction in pre-existing family insurance. Also, the welfare evaluation of public transfer policy can be biased if the strategic interaction between parents- and child-households is not accounted for adequately. With regard to the changes in state pension income amount, it just has a limited effect on elderly workers' retirement behaviour and motivation for savings. Moreover, the simulation results of the rise in retirement income show that the huge amount of intrafamily resource sharing observed in Korea could be partly explained by its relatively high poverty rate.

Future work needs to be conducted in a way that relaxes some of the assumptions made in this study and extends the forms of family insurance to non-financial support such as living or care arrangement. Although this study introduces an interaction between parent- and child-household, child-households are not allowed to save, and women's labour force choice is just treated as an event drawn in a random manner. However, if children are allowed to hold assets, the decision on upstream transfers does not just depend on current income, and they are able to spread the cost of transfers across time. Also, as various statistics consistently capture the emerging role of women in the labour force, the model needs to reflect the coordination of a couple's decision-making process more explicitly. Finally, there is relatively large literature modelling other forms of family supports. Financial support can be a good substitute for the time investment of care-giving for their parents or grandchildren, so the choice between financial and informal time support may play a relatively important role in accounting for observed intra-family transfers and bequest choice. These issues remain for future work to consider.

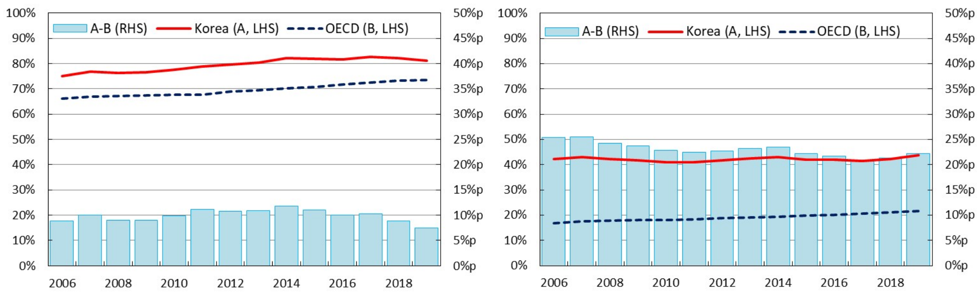
Figure 1.1 Incidence of Within Family Gross Inter-Vivos Financial Transfers



(a) Western Countries (b) Asian Countries

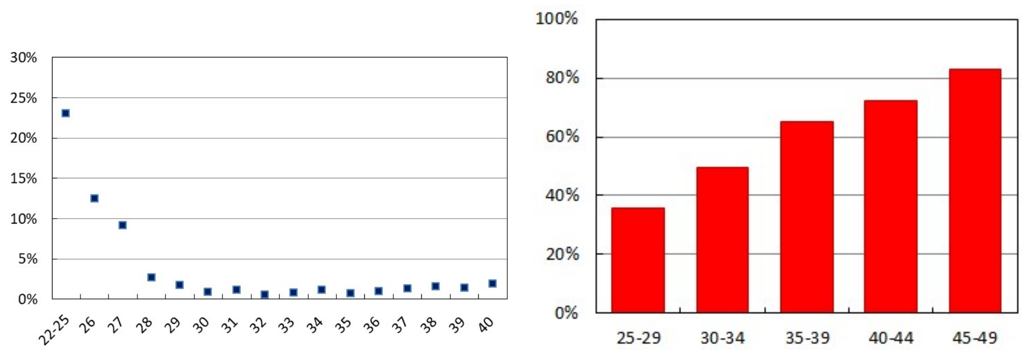
Sources: ?; HRS (2004); JSTAR(2010-2013); SHARE (2004); ?

Figure 1.2 Total Labour Force Participation Rate: Korea vs. OECD-Average



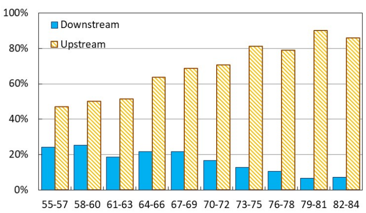
(a) Aged Between 55 and 64 (b) Aged 65 or More

Figure 1.3 Coresidence of Parents and child and IVFT Provision by Child's Age

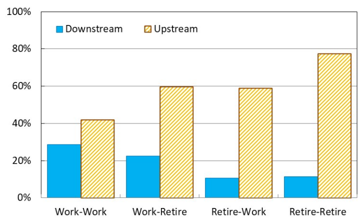


(a) Coresidence with Married Children (b) Incidence of Net-Upstream Transfers

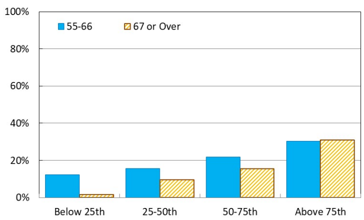
Figure 1.4 Share of Parents-Household Receiving and Providing IVFT



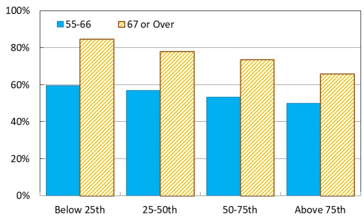
(a) The Proportion of IVFT Provision by Age Group



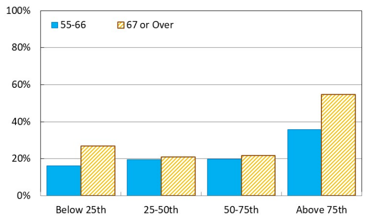
(b) By LFP Status Both Elderly Men and Women



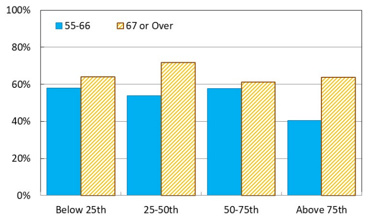
(c) Downstream: By Age & Wealth Quantile



(d) Upstream: By Age & Wealth Quantile



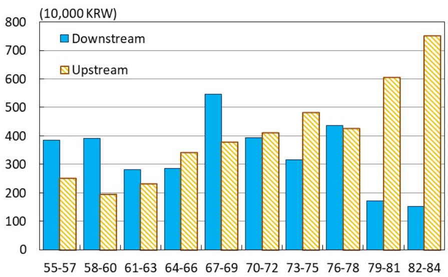
(e) Downstream: By Age & Earnings Quantile



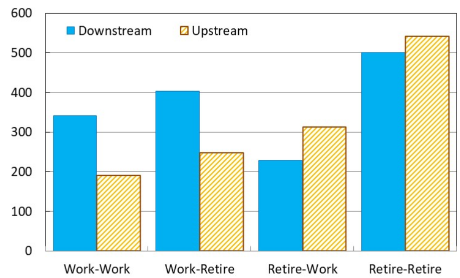
(f) Upstream: By Age & Earnings Quantile

Notes: The observations of transfers, which amount is below 300,000KRW are excluded. A household is regarded as an IVFT provider if the household provides transfers at least once given three year period given in the horizontal axis of panel (a). The observations of transfers, which amount is below 300,000KRW are excluded. Monetary values are deflated by the yearly CPI of the year 2015. The amount is shown in 10,000KRW. The amount of transfers is top coded at above top 5% (applies to figure 1.5)

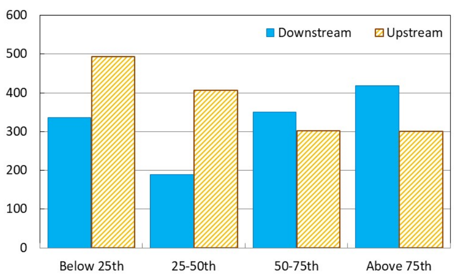
Figure 1.5 Amount of Parents-Households' Bidirectional IVFT



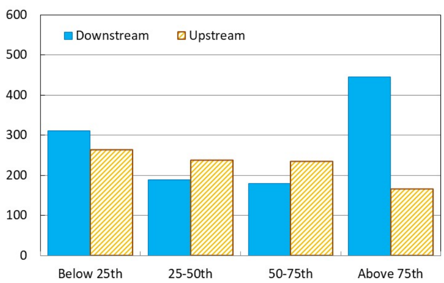
(a) By Age



(b) By Parent's labour Force Status

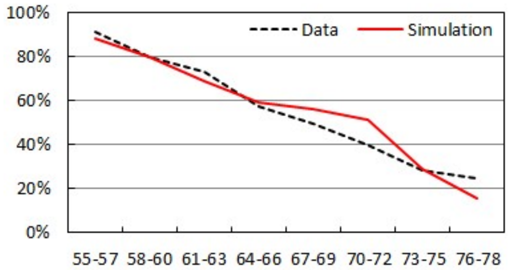


(c) By Wealth Quantile

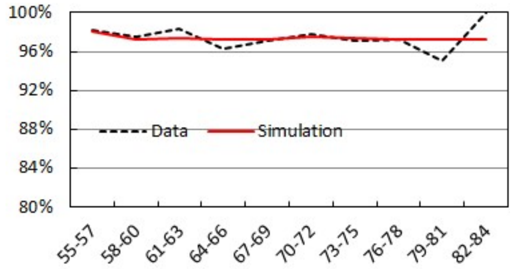


(d) By Earnings Quantile

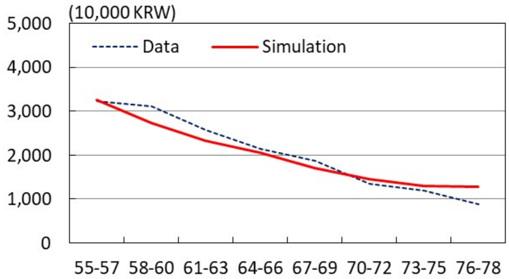
Figure 1.6 Model Fits: Empirical vs. Simulated Profiles of the Labour Force Choice



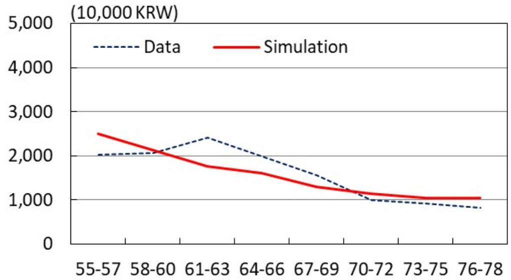
(a) Parent: LFP Rate



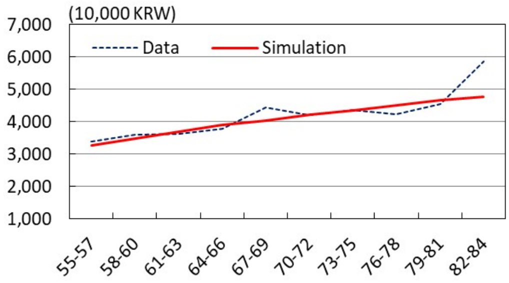
(b) Child: LFP Rate



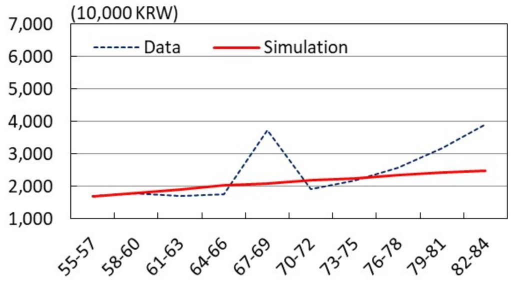
(c) Parent Earnings: Mean



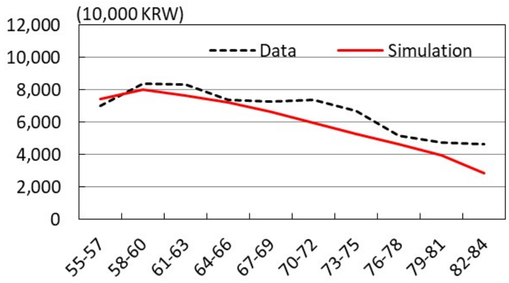
(d) Parent Earnings: Standard Deviation



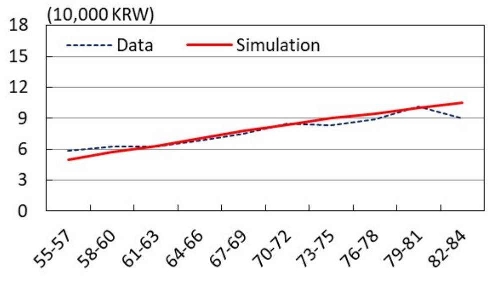
(e) Child Earnings: Mean



(f) Child Earnings: Standard Deviation



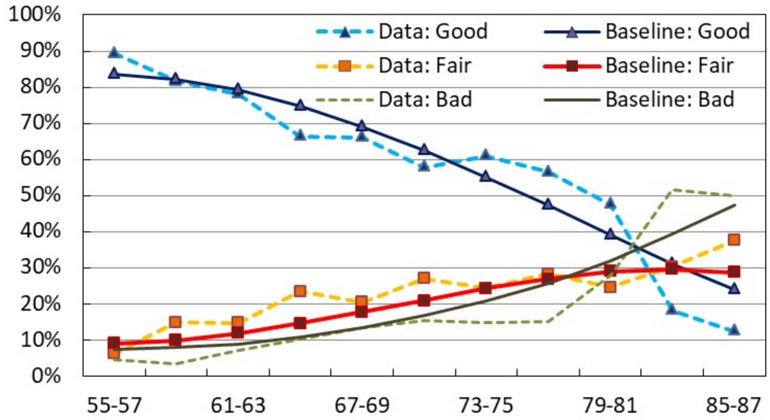
(g) Parent: Net Asset



(h) Parent: Out of Pocket Medical Costs

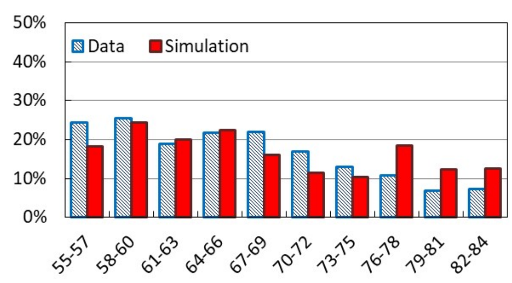
Note: Male-parent's and child's earnings show the average of post-tax yearly full-time or self-employed earnings

Figure 1.7 Model Fits: Empirical vs. Simulated profiles of Health Status

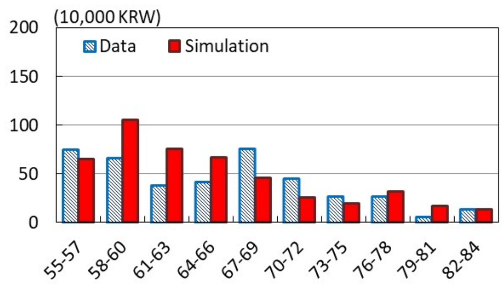


Note: Conditional on survivors at a given age group

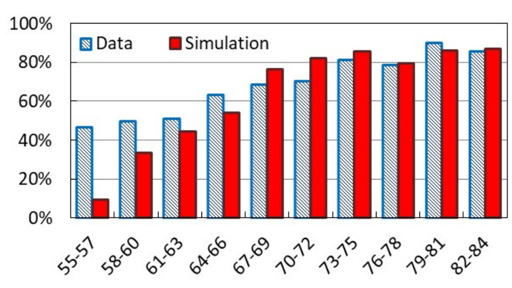
Figure 1.8 Model Fits: Empirical vs. Simulated Profiles of Bidirectional IVFT



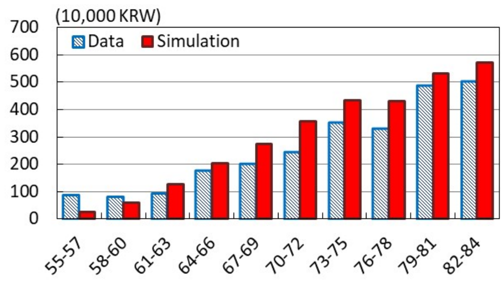
(a) Parent: Share of Providing IVFT



(b) Parent: Average Amount of IVFT



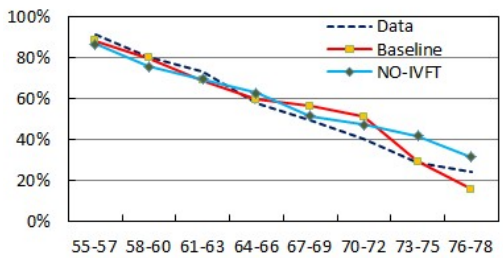
(c) Child: Share of Providing IVFT



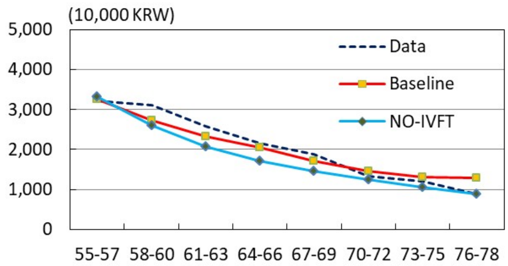
(d) Child: Average Amount of IVFT

Notes: The amount of down- and up-stream transfer shows the unconditional mean of net-transfer amount ($\overline{TR}_t^j = \frac{\Sigma_{i=1}^{N} TR_{it}^j}{N}$). 10,000KRW is approximately equal to U.S \$8.4

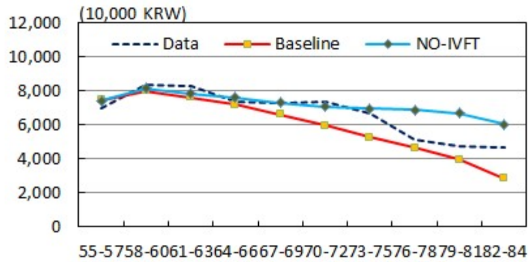
Figure 1.9 Comparison: Baseline vs. No-IVFT Profiles of Selected Variables



(a) Parent: LFP Rate



(b) Parent: Mean Earnings



(c) Parent: Net Asset

Note: 10,000KRW is approximately equal to U.S $8.4

Table 1.1 Sample Selection

Step	Sample Exclusion Rules	Number of Family	HH	Number of Obs. Family	HH
0:	Raw Data	4,329	7,102		59,143
1:	Delete Family Obs. Consisted of One Household (HH) or Whose Parents Form Separated HHs	1,525	3,910		25,380
2:	Exclude Family Obs. with More than One Independent Child HHs	1,367	2,734		13,704
3:	Drop Family Obs. Whose Age Difference Between the Oldest Parents and Child is less than 15	1,358	2,716	6,796	13,592
4:	Exclude Family Obs. with Single Parent	942	1,884	4,265	8,530
5:	Exclude Family Obs. with Non-Married Independent Child	637	1,274	2,787	5,574
6:	Delete Family Obs.: Male Parent's Age $<$ 55	604	1,208	2,623	5,246

Table 1.2 Summary Statistics by Household Type

Parents-HH	$Edu_i^p = L$	$Edu_i^p = H$	Child-HH	$Edu_i^c = L$	$Edu_i^c = H$
Prop.	48.0%	52.0%	Prop.	25.5%	74.5%
Age	66.7	65.8	Age	37.4	37.2
(Std.)	(6.62)	(6.55)	(Std.)	(5.95)	(5.15)
LFP Rate	58.8%	54.5%	LFP Rate	96.3%	97.8%
SP Age	62.4	61.8	SP Age	37.7	35.1
SP LFP Rate	27.4%	24.0%	SP LFP Rate	40.6%	45.3%
Net Asset	5,629	7,641	Net Asset	4,945	7,259
(Std.)	(7193)	(8024)	(Std.)	(6094)	(8060)
Pension Amount	410	664	Earnings	3,422	4,161
(Std.)	(358)	(652)	(Std.)	(1952)	(2442)
(Prop.)	(51.1%)	(48.4%)	SP Earnings	1,831	2,590
Earnings	1,791	2,908	(Std.)	(1019)	(1909)
(Std.)	(1482)	(2337)	Work hours	47.7	43.1
SP Earnings	1,244	1,680	SP Work Hours	41.8	40.6
(Std.)	(969)	(1441)			
Work Hours	49.7	50.0			
SP Work Hours	41.9	40.0			
ADL	0.47	0.32			
SEH	2.98	2.79			
Physical Limit	0.15	0.12			
OOP Health Costs	7.47	7.04			
Downstream	13.9%	12.8%	Downstream	11.9%	13.8%
Average Amt.	258	480	Avg. Amt.	348	375
Upstream	55.6%	49.4%	Upstream	49.3%	53.5%
Average Amt.	343	488	Average Amt.	346	371

Notes: Monetary values (net assets, pension amount, earnings, OOP health costs) are deflated by the yearly CPI of the year 2105 and expressed as 10,000KRW. The amount of down- and up-stream transfers over top 5% of each is replaced by each 95th percentile, respectively. The net-transfer amount are left-censored at 300,000KRW. 'Average Amt.' is derived by dividing the net-amount of transfers by the number of donor households. ADL and SEH denote Activities of Daily Living and Self-Evaluation of Health, respectively

Table 1.3 Proportion and Amount of IVFT by Motivation

	Downstream		Upstream	
	Proportion	Amount	Proportion	Amount
Anniversary Gift	35.4%	615	57.7%	169
No Particular Reason	45.7%	228	14.4%	186
Insufficient Living Cost	5.1%	648	23.5%	722
Supporting Grand Children	4.6%	444	2.3%	704
Purchase of House	2.9%	3,477	0.3%	734
Purchase Durable Goods	0.9%	290	0.2%	344
Supporting Running Business	0.9%	3,327	0.1%	83
Tuition Fee	1.2%	1,497	-	-
Paying Debt	0.9%	3,246	0.2%	306
Paying Health Cost	0.7%	433	1.2%	435
Others	1.6%	895	0.1%	207

Notes: The numbers in the table show the proportion of parents who provide or receive intergenerational financial supports and its amounts. The unit is 10,000KRW. Above Top 5% amount of upstream transfers are excluded

Table 1.4 SUR Estimates of Downstream and Upstream IVFT Incidence

	Downstream		Upstream	
	Coef.	S.E.	Coef.	S.E.
P: Log Net Asset	0.021**	(0.008)	0.004	(0.0133)
P: Log Pension	0.012	(0.016)	- 0.0515*	(0.026)
P: Participation	0.088***	(0.027)	- 0.204***	(0.045)
P: SP Participation	0.069**	(0.027)	- 0.227***	(0.045)
P: H-Type	-0.0096	(0.028)	- 0.042	(0.046)
P: SP H-Type	- 0.154***	(0.060)	- 0.030	(0.099)
P & PSP: H-Type	0.163**	(0.067)	- 0.103	(0.111)
P:Health-Fair	- 0.036	(0.029)	0.042	(0.048)
P: Health-Bad	- 0.013	(0.042)	0.048	(0.070)
C: Log Net Asset	- 0.0072	(0.0102)	- 0.0008	(0.0170)
C: Participation	0.074	(0.088)	0.067	(0.146)
C: SP Participation	- 0.065***	(0.024)	0.098**	(0.040)
C: H-Type	0.023	(0.051)	0.009	(0.084)
C: SP H-Type	0.020	(0.049)	0.022	(0.081)
C & CSP: H-Type	- 0.042	(0.063)	0.035	(0.104)
Year-Dummy	Y		Y	
Age-Dummy	Y		Y	
R2	0.135		0.149	

Notes: Standard errors are presented in parenthesis: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Male-parents whose age is between 55 and 74 are used. Top and bottom 1% of net assets and pension amounts are removed. Male (spouse) parents are categorized as the high education group if he (she) has received high-school or higher degree. The variable starting with P: (C:) contains the sociodemogrphic factors of parents (child) households. PSP denotes the spouse of male-parent, and the P & PSP (C & CSP) H-Type variable is used to capture possible interaction effect of parent's (child's) educational achievement. The transfers are left-censored at 300,000KRW. Estimated parameters for age- and time-dummies (2007-2016) are not presented in the table. The baseline definition on industry group is service sector

Table 1.5 Estimates of the Preference and Type-Assignment Parameters

Parameter	Definition	Baseline Coef.	Baseline S.E.	No IVFT Coef.	No IVFT S.E.
σ	Relative Risk Aversion	6.779	(0.0164)	6.005	(0.0224)
α	Consumption Weight	0.641	(0.0017)	0.544	(0.0019)
γ_P	Fixed Cost of Work (hours)	458.557	(42.2053)	491.857	(24.31053)
γ_{Fair}	Fixed Cost of Fair Health (hours)	658.596	(41.7866)	819.429	(172.6253)
γ_{Bad}	Fixed Cost of Bad Health (hours)	977.278	(93.7302)	970.450	(60.6827)
θ_B	Bequest Shifter	0.00007	(0.000006)	0.00049	(0.0001)
K	Bequest Curvature	2,050.535	(14.6458)	947.821	(17.0622)
b	Amount of UI Benefit	2,168.519	(19.0965)		
Λ_s	Job Separation Rate	0.026	(0.0021)		
Λ_{un}	1 - Arrival Rate of Job	0.072	(0.0046)		
η_1	Coeff. of Type-1 Parent's Altruism	0.666	(0.0382)		
κ_1	Coeff. of Type-1 Child's Altruism	0.011	(0.0005)		
η_2	Coeff. of Type-2 Parent's Altruism	0.623	(0.0424)		
κ_2	Coeff. of Type-2 Child's Altruism	0.015	(0.0010)		
η_3	Coeff. of Type-3 Parent's Altruism	0.510	(0.0424)		
κ_3	Coeff. of Type-3 Child's Altruism	0.024	(0.0015)		
λ_0^1	Type-1 Intercept	0.752	(0.0452)		
λ_1^1	Type-1 Coef. on Edu_i^p	2.285	(0.1962)		
λ_2^1	Type-1 Coef. on Edu_i^c	- 1.314	(0.0830)		
λ_3^1	Type-1 Coef. on $I_{\{Sib_i \geq 1\}}$	- 0.649	(0.0474)		
λ_0^3	Type-3 Intercept	1.067	(0.0770)		
λ_1^3	Type-3 Coef. on Edu_i^p	- 5.405	(0.4248)		
λ_2^3	Type-3 Coef. on Edu_i^c	2.436	(0.1751)		
λ_3^3	Type-3 Coef. on $I_{\{Sib_i \geq 1\}}$	3.306	(0.2768)		

Table 1.6 Estimates of the Earnings Parameters

Parameter	Definition	Baseline Coef.	Baseline S.E.	No IVFT Coef.	No IVFT S.E.
β_0^p	Parent: Constant	7.848	(0.0225)	7.746	(0.0118)
β_1^p	Parent: age_{it}^p	-0.187	(0.0010)	-0.214	(0.0075)
β_2^p	Parent: $(age_{it}^p)^2/100$	0.469	(0.0032)	0.287	(0.1169)
β_3^p	Parent: $hs_{it} = Fair$	-0.175	(0.0001)	-0.187	(0.1929)
β_4^p	Parent: $hs_{it} = Bad$	-0.374	(0.0019)	-0.301	(0.1541)
β_5^p	Parent: Edu_i^p	0.444	(0.0033)	0.499	(0.0247)
σ_{ξ^p}	Parent: Standard Error	0.639	(0.0047)	0.767	(0.0802)
β_0^c	Child: Constant	7.700	(0.0086)		
β_1^c	Child: age_{it}^c	0.066	(0.0002)		
β_2^c	Child: $(age_{it}^c)^2/100$	-0.194	(0.0012)		
β_3^c	Child: Edu_i^c	0.219	(0.0011)		
σ_{ξ^c}	Child: Standard Error	0.477	(0.0029)		

Notes: $age_{it}^p = 1$ if male-parent's age is between 55 and 57. Given $age_{it}^p = 1$, age_{it}^c is 1, 2 or 3 if Δ_i is 25, 28 or 31. Afterwards age_{it}^p (Age_{it}^c) is increased by one-unit in every three years

Table 1.7 Transition Probabilities Between Provision and Non-Provision of IVFT

		Status in t+1			
		Downstream		Upstream	
	Status in t	Provision	Non-Provision	Provision	Non-Provision
Empirical	Provision	77.4%	22.6%	90.1%	9.9%
(A)	Non-Provision	7.2%	92.8%	40.9%	59.1%
Simulation	Provision	76.4%	23.6%	95.8%	4.2%
(B)	(B-A)	(-1.0%p)	(1.0%p)	(5.7%p)	(-5.7%p)
	Non-Provision	3.2%	96.8%	25.2%	74.8%
	(B-A)	(-3.9%p)	(3.9%p)	(-15.7%p)	(15.7%p)

Notes: The empirical and simulated profiles for families whose male-member's age is between 55-84. The figures in the table are derived by averaging the proportion of people included in specific case. A household is counted as a donor of IVFT if providing transfers at least once during three years corresponding to the given period t (a period in the model corresponds to 3 years)

Table 1.8 The Effect of Expansion of BPS and NPS on Major Lifecycle Profiles

		IVFT			No-IVFT		
		Baseline	New-BPS	New-NPS	Baseline	New-BPS	New-NPS
LFP^p	(Proportion)	56.2%	55.7%	55.4%	58.3%	34.5%	55.6%
A_{t+1}	(Amount)	59.66	61.15	59.38	72.03	59.95	73.67
TR^p	(Likelihood)	16.6%	18.6%	18.7%			
	(Amount)	0.47	0.55	0.52			
TR^c	(Likelihood)	63.7%	62.7%	62.4%			
	(Amount)	3.01	2.84	2.88			
c^p	(Amount)	29.68	30.27	29.99	22.19	24.52	22.43
TR^G	(Proportion)	57.0%	68.3%	49.4%	47.0%	76.8%	39.9%
	(Amount)	1.55	3.54	1.50	1.48	3.55	1.45

Notes: The figures in the table show the average of simulated profiles of family which male parent's age is between 55-84. The amounts are expressed in million KRW. The average of simulated LFP rate profiles for male-parent is derived by individuals aged 55-78. The average of simulated incidence as well as amount of government support is derived by individuals aged 64-84

Chapter 2

A Long Journey Toward Retirement: A Dynamic Model of Labour Supply and Retirement with Self-Employment

2.1 Introduction

The labour force participation (LFP) of elderly people has become a major social issue. As the trend in population ageing puts more pressure on assuring financial stability in retirement and sustainability of social security systems, most developed countries have been introducing policies encouraging the delay of retirement. Recently, the interest in senior self-employed has been rising as bridge employment, and there has been emerging attention on the factors that affect the decision of elderly people approaching near the end of their career to become their own boss.

Empirical evidence suggests that the self-employment rate in the U.S. increases rapidly with age. Figure 2.1(a) presents that the self-employment rate among elderly people is around four to eleven times higher than that of the youth. This implies that becoming his own boss is more important for the elderly. However, despite its importance on the well-being of older people and contribution toward the economy as well as the stability of the social security system, entrepreneurship by older people has received relatively little attention.[1] In particular, retirement literature using dynamic models usually excludes self-employed from the analysis or treat self-employed in the same way as paid-counterparties.

[1]In much of the literature, the terms self-employment and entrepreneurship are used interchangeably (?). Thus, self-employment and entrepreneurship are interchangeable hereafter.

Using the U.S. Health and Retirement Study (HRS), I document that self-employment has several characteristics that distinguish it from paid-employment. First, the median hourly wage rate of self-employed is less than that of full-time workers, however, due to the high variance in their earnings, the average hourly wage for self-employed exceeds that for paid-workers. Second, the nature of the work involved is different. Self-employment is associated with work environment such as flexibility in deciding their work schedule. Third, the average length of self-employment spells is shorter than full-time workers as unsuccessful senior self-employed persons quickly close their business down. Finally, those who have experience in self-employment tend to maintain a relatively high level of life-time savings. These features reveal that self-employment is different and cannot be combined with paid-employment.[2]

I develop and estimate a discrete choice dynamic programming model of sector choice and retirement to understand complex patterns of elderly people's labour force decision. The model captures all the characteristics of self-employment explained above. Two key features of the model are worthy to mention. First, the model allows various mechanism which drives selection into self-employment. For instance, due to the differences in sectoral characteristics and worker heterogeneity, the selection issue naturally arises. In order to capture the self-selection, the model introduces preference heterogeneity, sectoral differences in earnings and flexibility in working hours, effective social security tax rates, and health condition. These lead workers to choose a specific career and make a transition between paid-job, self-employment, and retirement.[3] The second feature is the introduction of the learning process. Although becoming self-employed are generally associated with greater uncertainty, agents can gradually learn about their own ability as an entrepreneur and partly reduce initial uncertainty by observing the performance of their business (**??**).[4]

In the context of retirement, having a proper understanding of the underlying mechanism of elderly people's entry into and exit from the self-employment sector is particularly important for policy-makers. Due to the importance of running their own business as a source of innovation and bridge jobs in the retirement transition, many governments have provided various kinds of programs to support older people in business start-up activities. These policy interventions may have an influence

[2] **?** document that self-employment has some distinguishing features which motivate elderly people to open their own business.

[3] In this study, 'career' implies the choice of sectors between paid-job, self-employment, and retirement, and the words career and sector are interchangeable.

[4] The information structure in this study is assumed that individuals in the model observe their own paid-sector productivity and just know the distribution of self-employment sector productivity.

on the dynamics of retirement and serve a function in encouraging more elderly people to work who would otherwise leave the labour force. Thus, it can not only contribute to security in retirement but also mitigate the rise in social security costs.

The model is estimated by the method of simulated moments. The constructed model produces reasonable parameter estimates and properly generates the rich patterns of entire elderly males' life-cycle choices observed in the HRS between 1992-2014. Estimates reveal that around half of elderly men exhibit a stronger preference for running their own business than working for someone else, and the initial uncertainty about self-employment earnings decreases quickly as gaining more entrepreneurial experience. In order to understand how elderly people in different sector adjust their labour supply behaviour, the model is used to explore the effect of temporary and permanent changes in before-tax wage rates on individuals' labour supply choice. First, I estimate the response to transitory changes in wages. The results show that the economy-wide aggregate elasticities of labour supply rapidly increase with age. In particular, the majority of labour supply changes caused by transitory wage shocks is explained by the intensive margin, and self-employed adjust their behaviour more flexibly than wage-earners. With regard to permanent wage changes which occur from the age of 60, the estimated aggregate elasticity is 0.39 decomposed into 0.14 of intensive and 0.25 of extensive margin. Moreover, comparing the wage changes restrictive to paid-sector with those only for self-employed, there is substantial heterogeneity in labour supply response across sectors.

The estimated model is used to perform two sets of policy counterfactuals; one is examining elderly people's response to the 25% reduction in social security tax rates, and the other is self-employment subsidies offered as a form of one-time \$30,000 lump-sum support.[5] The policy counterfactual of tax-cuts suggests two important findings. First, the policy contributes to strengthening elderly people's security in retirement, however, it has a limited effect on encouraging more people to delay retirement if the tax-cut starts to be applied to too old people. Second is that due to the difference in effective tax rates levied on paid-workers and self-employed, the changes in payroll tax affect elderly workers' sector choices, and people in each sector respond to the tax-cut differently. With regard to the self-employment subsidy, regardless of the intervention timing, it encourages more people to venture into a business and has a positive effect on both security in retirement and entrepreneurial

[5]The tax is levied on both employees and self-employed at the same rate of 12.4%. In the case of paid-employees, half of the taxes (6.2%) is shared by employees, so the effective social security tax rate for employees is 6.2% of earnings. However, self-employed have to bear the whole tax on their own.

quality. Moreover, the earlier age the policy is implemented, the greater the positive effects on security in retirement. However, the costs and benefits of the policy significantly depend on the age when the intervention is made and rely on whether the policy effect is evaluated in terms of short- or long-run perspective.

I also contrast the implication of my model relative to a model without the self-employment sector. To do this, I newly derive another set of simulated profiles from the model which does not allow self-employment as a career alternative to paid-employment.[6] As the self-employment sector is excluded from the model, the results cannot represent the entire elderly people's work and retirement choice appropriately.[7] Comparing it with the entire sample and full-model, the model without self-employment sector underpredicts the LFP rate by 22.0% (8.4%p) and 21.8% (8.3%p) on average, respectively.[8] One possible explanation for this underprediction is that the simpler-model cannot adequately capture the distinguishing characteristics of self-employment and the motivation of elderly people who change their career instead of choosing retirement. Under the model without entrepreneurship, individuals on the margin of work and retirement are more likely to choose to retire when marginal negative changes in working conditions occur. In this respect, self-employment can play a role in delaying retirement. Moreover, it confirms the presence of selection bias. Although models excluding self-employment seem to perform well in matching the subsample, prediction under the models would be biased and may not properly capture work and retirement choice for entire elderly people.

The remainder of this paper is structured as follows. In section 2.2, I review the related literature. Section 2.3 describes the data. Section 2.4 explains the structure of the model. Section 2.5 introduces the identification and estimation strategy. Section 2.6 provides the parameter estimates and the overall model fits. Section 2.7 explains the labour supply response to temporary and permanent before-tax wage changes. Section 8 focuses on several counterfactual regimes, and section 2.8 concludes.

[6] *i.e.* If an individual wants to participate in the labour force, he should have a salaried-job, and becoming his own boss is not allowed.

[7] For instance, some studies define workers as people who are not self-employed. However, individuals who participate in the labour force in the form of either working for someone else or running their own business might not be a random sample from the population. Thus, the use of individuals who have never run their own business would not well represent the work and retirement choice of the entire population.

[8] In the sample, the male workers' LFP rate for ages 57-79 is 38.0% on average, and the full-model just underpredicts elderly people's participation choice by 0.1%p (LFP rate: 37.9%). However, the predicted average participation rate from the model which does not consider entrepreneurship is 29.6%.

2.2 Literature Review

The retirement literature has recognized that labour force transition toward the latter parts of the worker's career consists of various states. Before retiring from the labour force completely, many people go through several stages which include reverse flows of retirement (**??**). Considering such multidimensionality of retirement decisions and the increasing role of uncertainties about earnings, health status, survival, and medical expenses at older ages, a structural approach is particularly suitable to account for complex incentives of individuals who are nearly approaching the end of their careers.

Recent studies construct integrated models allowing for a transition between the states of full-time work, partial retirement, and full-retirement (**???**). However, comparing it with individuals' career choice from paid-work to retirement, limited progress has been made on the transition between paid-job, self-employment, and retirement at older ages. I build on the model suggested by **?** who analyses older workers' work and retirement choice. He allows that agents are heterogeneous in their health and asset-holdings and choose consumption and hours of work. The innovation of my model is that I allow for the selection into self-employment jointly with paid-job and retirement and introduce various mechanisms to capture entry into and exit from self-employment.

Most dynamic models of discrete career choice between paid- and self-employment focus on young or early middle-aged people (**???**), and relatively scant studies have been conducted on how the transition into self-employment is different at older ages. This is an important gap in the literature. As the elderly are in their latter part of life, comparing it with the youth, different forces such as planning for retirement, health deterioration, putting higher values on flexibility or insufficient chances to find profitable jobs lead them to enter into self-employment.

With regard to the information structure, this study is closely related to the papers such as **??** which introduce the learning process and focus on the uncertainty surrounding the career choice. The model structure suggested by **?** is closest to this study. They construct a structural model of career choice between paid-job and self-employment, and risk-neutral agents in their model are allowed to learn about their entrepreneurial ability through Bayesian learning. However, my paper differs from their paper in three aspects. First, I include risk-aversion in the model. Considering the higher variance of earnings in the self-employment sector, the attitude towards risks plays an important role in the sectoral choice. Second, I model savings, bequest motives, and SSB application. The analysis of consumption-saving and timing of drawing SSB is particularly important to capture the transition from work to retirement. Finally, agents are allowed to choose working hours including retirement choice. As the HRS shows that the majority of people attribute the decision of changing career from paid- to self-employment to enjoying more flexibility in deciding the working schedule, the model needs to properly reflect such an incentive.

? builds a model of sectoral choice and introduces risk-aversion as well as savings choice. He assumes that individuals need to learn about their ability in both paid- and self-employment sectors. This would be more realistic and allows for avoiding asymmetry of information structure. I adopt a partly observed and correlated information structure. This would be more restrictive, however, comparing it with his study which investigates the life-time career choice between the initial transition to the labour force and exogenous retirement at the early 50s, I focus on elderly male-workers whose age is 56 or older. Thus, through past experience, many older workers get opportunities to have relatively precise information about their own marketable wage. Also, as my model already includes many other mechanisms that he does not consider such as retirement, drawing SSB and working hours choices, I sustain the assumption on the information structure for reducing the computational burden.

It is beyond the scope of this paper, however, a growing body of literature has explored the relationship between personal-traits and entrepreneurship.[9] **?** divides the patterns of self-employment into seven groups and shows systematic differences among people in different groups. **?** develop a structural model which treats socio-emotional skills as major determinants of self-employment selection and allows for the choice of asset investment for the business. Contrary to these papers, however, I implicitly assume that diverse personal traits are absorbed by sector-specific abilities and focus more on work and retirement choice.[10]

2.3 The Data

For the estimation of the model, the HRS for the years 1992-2014 is used. The HRS is conducted by the Institute for Social Research at the University of Michigan supported in large part by National Institute on Ageing. The data is a biennial

[9] Although age, experience, access to capital, heterogeneous non-pecuniary benefits from self-employment, and having entrepreneurial parents are considered as having a close relation with becoming self-employed, there is no consensus about which factors are the most important drivers and little evidence on the underlying mechanism (**?**).

[10] With regard to the amount of fixed assets usually required to run a new business, the negative effect of ignoring investment choice would be limited. For instance, **?** shows that the median amount of fixed assets employed by new business is lower than $10,000 in most industries.

national longitudinal panel survey that contains 12,652 people in 7,702 households in 1992-study. The sample is nationally representative of Americans aged 51 or older since 1992. In addition to the respondents from eligible birth years, the survey interviewed the spouses or the partner of a respondent, regardless of age. The survey elicits one of the largest and comprehensive information on demographics, income, assets, debts, health, job status, social security, and other transfers from the government. The sample consists of households from 6 different cohort groups.[11] The baseline survey is conducted in 1992, and the follow-up interviews have been subsequently conducted every two years.

2.3.1 The Sample

I start with 33,736 individuals in the RAND HRS. Of those, 6,263 individuals who have skipped the survey at least once after their baseline wave are dropped, and 2,988 individuals who do not report their work status information are excluded. 10,831 individuals who are never married or either married or divorced during the period under study are additionally dropped.[12] To sustain the homogeneity of the sample, couples whose age difference is within 10 years are remained. This reduces the number of individuals in the sample to 12,352. After then, I drop 461 couples (922 individuals) whose real wages are less than \$1 per hour or greater than \$300 per hour and exclude additional 345 couples with over \$1,500,000 in non-housing net assets (the definition on the variable is explained in the next subsection).[13] In addition, 10 households in which both the household head and their spouse are the same gender are dropped. Due to the structural differences from the rest of the economy, 181 households in which at least one of the couple members is employed in agriculture, forestry, or fishery industries are excluded. Finally, I drop additional 344 couples in which at least one of the household members has never worked in his or her life. These procedures leave a final sample of 4,835 households and 47,344 couple-year observations.

[11]The initial HRS cohort, who was born between 1931 and 1941, was interviewed in 1992. The AHEAD cohort born before 1924 was initially a separate study and interviewed in 1993. The Children of Depression (CODA) cohort born 1924-1930 was first interviewed in 1998. The War Baby (WB) cohort born 1942-1947 and the Early Baby Boomer (EBB) cohort born 1948-1953 were first interviewed in 2004-2010, respectively.

[12]In this paper, I do not account for family dynamics such as marriage or divorce. Couples are only allowed to be separated by losing one's spouse.

[13]All monetary amounts are adjusted for inflation and expressed in 2000 dollars.

2.3.2 Identifying Major Variables

In this study, involuntary unemployment is not allowed. In order to avoid the ambiguity that may arise in defining retirement, an agent is defined as a retiree if he is not in the labour force.[14] However, retirement is not an absorbing state, and thus retired people can return to work whenever they want. If an individual is working as a full-timer, he is regarded as a full-time worker. If he reports his mode of participation as a part-timer or both part-timer and partly retiree (the agent is working part-time and mentions retirement), he is defined as a part-time worker. Full- and part-time workers are categorized as paid-workers. I define self-employed as people who regard them as self-employed in their main job.[15]

In order to measure individuals' net-wealth, total non-housing net-wealth is used. The total non-housing net wealth is calculated as the sum of the appropriate wealth components (IRA, Keogh accounts, stocks, mutual funds, CDs, government saving bonds, T-bill, bond funds, money market accounts, investment trusts, checking accounts, saving accounts, and the net-value of other savings) less debt. Thus, the value of primary and second housing assets and related debts (such as mortgages and home loans) are not included in the net assets. Individual's net-assets is referred to as assets here and elsewhere in this study. With regard to the earnings, hourly real wage rates are used.

2.3.3 Summary Statistics

Table 2.1-2.2 and figure 2.1-2.4 show the descriptive statistics of individuals in the sample. The statistics reveal that self-employment cannot be combined with paid-employment, and thus running own business is needed to be treated differently from paid-workers; broadening the choice of current paid-workers and potential labour force entrants.

Table 2.1 provides several important characteristics of self-employment that distinguishes it from paid-counterparty. First, the expected hourly wage of self-employed is higher than those of salaried-workers. The hourly wage rate for self-employed is around 26% higher than that of full-time workers. Second, individuals face more uncertainty on their earnings. Comparing it with paid-workers, hourly wage rates in the self-employment sector are much more polarized, and larger

[14] *i.e.* if an individual chooses 0 working hour, he is regarded as a retiree. This definition is similar to **?**. They do not distinguish between unemployment and non-participation in the labour force.

[15] The HRS asks "Do you work for someone else, or are you self-employed regarding the current main job". If an agent replies that he is self-employed, he is regarded as self-employed.

shares of wages are very high and low.[16] The median hourly wage of self-employed is \$1.2 lower than that of full-timers, and the standard deviation of hourly wages in self-employment is remarkably higher than that of full- and part-timers. Third, the nature of work involved in the self-employment sector is different, so these allow self-employed to stay in the labour force longer and enjoy more flexibility than paid counterparties. Self-employed work 350 hours less per year than full-timers on average, and its standard deviation is more than twice that of full- and part-time workers. As a result, elderly people in the self-employment sector have a stronger attachment to the labour market. For instance, the average age of self-employed is 3.6 years older than full-time workers.

These differences between paid- and self-employment are also reflected not only in the earnings but also in the dynamics of asset holdings and job-spells. Figure 2.2 provides another reason for the need to separate the choice of becoming his own boss from a having paid-job. Panel (a) shows that self-employment experience impacts on asset holdings of people aged 56-79. Although the gap is shrinking with age, having been running own business is associated with sustaining a relatively high level of asset holdings and can play a role in strengthening financial security in retirement. Looking at more closely, comparing it with individuals who change their career frequently (newly opening a business two times or more during the period under study), those who have been self-employed since the initial wave of the HRS (*i.e.* individuals who have not changed their career to paid-employment are categorized in this group, continue SE) and those who open their business just once during the period under the study (once) have more assets (panel (b)). Figure 2.3 shows another distinctive feature of self-employment which are reflected in job-spells. As the least successful entrepreneurs go out of business quickly, self-employed are similar to part-timers. On the other hand, as profitable self-employed are more likely to keep their business, they also have the characteristics of full-time workers.

Distinctive features between paid- and self-employment result in different patterns of elderly workers' career choice across sectors. Figure 2.1(b) shows the elderly men's LFP rate by age. As the number of paid-workers declines, the overall LFP rate decreases from 81% at age 56 to 11% at age 79. In particular, the drop is prominent between the ages 62-66 which correspond to the time at which the earliest and full Social Security Retired Worker Benefit applications are eligible.[17] However, in the case of self-employed, such a large drop has not been observed over the

[16] See **??**

[17] The age when individuals get the right to draw Social Security Retired Worker Benefits is the age of 62 and is referred to as Early Eligibility Age (EEA). Full Retirement Age (FRA) is the age that individuals can draw unreduced retirement benefits. FRA has been risen from age 65 in 2002 to 67 in 2027.

same time period.[18] The self-employment rate gradually decreases from 13% to 4% between the ages of 56-79. The relatively high self-employment rate is not just caused by the reluctance of self-employed persons returning to paid-job or their relatively strong labour force attachment but caused by frequent entry into and exit from self-employment. Figure 2.4(a) describes the entry- and exit-patterns of self-employed. It shows that moving into and exit from self-employment happen frequently.

Table 2.2 summarizes the transition probabilities between paid-employment, self-employment, and retirement for every other year. The table shows that the probability of switching from paid-job to self-employment rises as people grow older, and self-employed are more likely to stay in the labour force for a longer period. Before the age of 67, 2.1% of workers switch their career from paid-job to self-employment. However, this figure increases by 15.3%p (2.1% → 17.4%) for the age group 67-79. Moreover, individuals in self-employment are more likely to stay in the labour force than paid-workers. Before the age of 67, 6.8%p more paid-workers leave the labour force than self-employed, and this trend is continued for the age group 67-79.[19] One possible explanation is that self-employment play a role in delaying retirement and improving security in retirement. This is because the self-employed can enjoy more flexibility in their hours of work decision, and if successful, they can expect much higher compensation. Moreover, unsuccessful self-employed can reverse their decision, and it does not cost them much (**?**).

2.3.4 Retirement and Career Transition Motivation

Defining the major determinants which lead people to change their career or choose retirement is not straightforward, and there is a large gray area among diverse kinds of factors. Therefore, before executing the structural analysis, this section provides a preliminary understanding and some pieces of evidence on the major motivation of people who switch their career rather than providing formal evidence. In order to understand more about the reasons of workers who switch their career or leave the labour force, the HRS survey questionnaires answered by workers who change their employment status since the last interview are used.[20] Because the questionnaires request respondents to provide an objective reason for leaving their previous job, comparing it with other survey results which contain a subjective evaluation on

[18]Between the age of 62 and 66, the proportion of paid-workers and self-employed decrease by 19.9%p (49.4% → 29.5%) and 1.0%p (10.0% → 9.0%), respectively.

[19]From paid-job to retirement 56.5% / From self-employment to retirement 50.2%.

[20]In order to retain a sufficient sample size, this subsection uses all the elderly workers aged 50 or over who answer the questions about the motivation of career transition or leave the labour force between 2002 and 2014 surveys.

leaving their job, the results are less susceptible to be contaminated by justification bias.

The reasons for retirement and career transitions in this section are categorized according to the classification suggested by **?**. Three key insights can be derived from the motivations of transition and retirement. First, the major factors which incentivise people to change their career and leave the labour force are substantially different across sectors. Second, individuals in the self-employment (SE) sector tend to enjoy more flexibility in deciding their work schedule and have more control over the working environment. Third, career changes between paid-job and self-employment occur actively even among people who are approaching the end of their working life.

Reason for retirement: Panel 1 of table 2.3 shows the reasons for male workers in different sectors to decide retirement. Overall, one-third of full-time (FT) workers and nearly half of self-employed perceive their retirement as “forced". Regardless of sectors, a nearly similar portion of workers has left their job due to the deterioration of employment constraint. However, there are considerable differences in detail. Comparing it with FT-workers who answer that 14.6% of their retirement are caused by the destruction of an existing job, 27.4% of self-employed and 23.0% of part-time (PT) workers attribute decision of leaving the labour force to business closure or being laid-off. 11.5% of FT-workers point the negative changes in working condition out as the reason for retirement, while only 3.2% of PT-workers, and 1.1% of self-employed insist on the same reason for their transition. Most of the differences in the relative proportion of involuntary retirement by sectors come from deterioration of health status. Self-employed are three times as likely as workers in the FT-sector and 1.5 times as high as PT-workers to have been forced to retire due to deterioration of health.

On the other hand, nearly two-thirds of FT-workers perceive their retirement as a voluntary transition, and most of them are initiated by an incentive to enjoy more leisure.[21] However, just around 40% of self-employed attribute their retirement as voluntary. None of them points enjoying more leisure out as a retirement motivation, and 90% of their voluntary retirement are due to spontaneous business closure. In the case of voluntary transition from PT-job to retirement, it is mainly caused by a desire to enjoy more leisure, however, the proportion is nearly 20%p less than that of FT-workers. Regardless of the worker's current career, other sources such as

[21]The result is similar to previous research. For example, **?** uses males who do not report self-employment (SE) spells during the period under study and shows that 61.4% of FT workers perceived their retirement as "wanted" rather than "forced"

financial incentives or changes in external circumstance do not play an important role in deciding whether to retire voluntarily or not.

The results in this section clearly indicate that the major forces which motivate workers to choose retirement are considerably different across sectors. Most FT-workers voluntarily opt for retirement to enjoy more leisure, however, a much smaller share of PT-workers consider it as a reason for their retirement and such a tendency is more pronounced for self-employed. These partly reflect the fact that, in order to maintain FT-job, individuals are required to work more than a certain amount of time (usually at least 35 hours per week or more) and PT-workers are paid far less amount of hourly wage than FT-workers.[22] Therefore, if paid-workers want to reduce their working hours by more than a certain amount of time and enjoy more leisure, they need to accept a considerable amount of pay cut. In this respect, becoming his own boss can be an alternative because they do not work under someone's instruction and enjoy more flexibility in deciding their own schedule, job duties, location, or work intensities. However, the high uncertainty on the chances of success in the SE-sector or relative preference for the paid-job prevents elderly people from opening a business easily.

Career transition motivation: Panel 2 of table 2.3 summarizes the reasons for changes in the mode of LFP. Around 30% and 37% of changes from self-employment to paid-job (SE to PJ) and vice versa (PJ to SE) are perceived as "forced", respectively. The contribution of business closure or lay-off is almost equally likely to cause workers to switch their career, however, the negative changes in working condition cause great differences in the portions of workers who have left their previous career involuntarily. Although 6.1% of workers who left their PJ and newly become entrepreneurs point negative changes in working condition out as the reason for their career switch, none of SE to PJ transition is caused by the same reason. These results reflect another important characteristic of becoming self-employed: becoming his own boss allows for having more control over work.

Nearly two-thirds of the PJ to SE transition was due to voluntary reasons. One of the remarkable differences is that no workers who make SE to PJ transition answers leisure as the reason for their switching, however, 16% of PJ to SE transition explained by enjoying more leisure. In addition, nearly a quarter (23.7%) of workers who left their FT-job but still stay in the paid-sector as part-timers attribute a desire of enjoying more leisure to their reason for transition. These results equally show that one of the important motivations which cause people to change their

[22] **?** shows that workers who work 1,000 hours per year are paid 25% less per hour than workers who work 2,000 hours per year.

career is enjoying more leisure, and this encourages elderly people to open their own business for having more flexibility in deciding their hours of work. Becoming self-employed involve much more risk-taking, so 30%p more workers who make FT to SE transition voluntarily quit their previous job and open their own business than those who make FT to PT transition. Also, more than 90% of voluntary SE to PJ transition is explained by spontaneous quit. These results correspond to the gradual decrease in the proportion of self-employed with age. Although a relatively high proportion of people opens their business, unprofitable self-employed go out of business quickly. As a result, the SE rate remains stable and gradually decreases with age.

2.3.5 Empirical Motivation of Learning

The learning process is first proposed by **?**, and since then, the relationship between ability and learning has been widely discussed in the literature (**????**). These studies show that job mobility decreases with the accumulation of work experience, and a correlation between the high wage and the tendency to stay in the same occupation is evidence of learning. Table 2.2 and figure 2.3 support the evidence of learning; the transition between paid-job and self-employment occurs quite frequently, and profitable self-employed are more likely to stay in their business. Figure 2.4b also illustrates that such a transition does not occur in a random manner. The lines of the figure show the hourly wage rate of self-employed over consecutive self-employment spells. In general, the hourly wage rate increases over job-spells, and workers who run their own business longer period are more likely to receive a higher wage. Moreover, self-employed who stay longer in their business receive strictly higher wages in their first two years.

The fact that more than half of people who change their career from paid-job to self-employment experience wage drop is also consistent with the importance of the learning process. 52.4% of self-employed having paid-job in the previous wave earn less than they did before. The median new self-employed persons receive \$0.34 less hourly wage than their most recent year of paid-job wage, and among people who experienced a drop in wages in the process of change from paid- to self-employment, their hourly wage rate is just 46.9% of that they received in the paid-job on average. These suggest that elderly workers are willing to take on the possible transitory drop in earnings related to career transition from paid-job to self-employment in order to have a chance to learn about their potential. By learning through running their own business and accumulating managerial experience, people who have relatively high ability in the self-employment sector can recognize their ability. As a result, they are willing to endure temporal loss, and people with relatively high potential are more likely to stay in their business for a longer period. On the other hand, people who are lack of entrepreneurial talent close the business swiftly.

2.4 Model

This section describes a dynamic discrete finite-horizon model that captures utility over earnings and preferences of people who are close to retirement. The model structure of this study builds on the integrated model suggested by **?**, however, in order to capture distinctive characteristics of self-employment and to reflect self-selection of heterogeneous individuals into different sectors, I allow for the selection into self-employment jointly with paid-employment and introduce a learning process which allows people to partly reduce initial uncertainty by observing the performance of their own business. The unit of analysis is married elderly couples, however, they are treated as a single decision-maker, and a female member's labour force choice is made in a random manner.

In each discrete period t, an individual i chooses between working either in the paid- or self-employment sector and retirement and makes Social Security Retired Worker Benefit (SSB) application, hours of work, asset holdings, and consumption choices. When making these choices, individuals face three types of uncertainty: health status, medical expenditures, and labour earnings. After individuals make each period optimal choices, these shocks occur at the end of the period. An individual who is not in the labour force is referred to as a retired person, however, retirement is not an absorbing state. Thus, individuals can return to work whenever they want. In each period, an individual's health status is either good, fair, or bad. Health status has effects on productivity, medical expenditure, the relative importance of consumption and leisure, time endowment, survival probabilities, and spouse's labour supply outcomes. The constructed model is used to account for sectoral mobility patterns and retirement choice over the life-cycle.

2.4.1 Choice Set

In each discrete period t, individuals make both discrete (the mode of LFP k_{it}^j and collecting SSB B_{it}) and continuous (saving a_{it+1} and hours of work h_{it}) choices. I denote a variable including both discrete and continuous choices by d_{it}^j:

$$d_{it}^j \in \{k_{it}^j, a_{it+1}, h_{it}, B_{it}\}, \tag{2.1}$$

where d_{it}^{j} refers to the set of choices made by an individual i who chooses a career j at time t.

The decision process can be described as follows. First, each individual makes a career choice. Then, they optimally choose savings, social security benefits application, and hours of work conditional on chosen discrete career alternatives.

Discrete choices: The first discrete choice variable is the mode of LFP. Non-participation is not an absorbing state, and thus they can always return to work after a period of inactivity. Thus, the participation mode takes on the forms of paid-job (PJ), self-employment (SE) or retirement (RE).[23]

$$k_{it}^{j} = \begin{bmatrix} 0 & if\ individual\ i\ chooses\ a\ career\ j = RE\ at\ time\ t \\ 1 & if\ individual\ i\ chooses\ a\ career\ j = PJ\ at\ time\ t \\ 2 & if\ individual\ i\ chooses\ a\ career\ j = SE\ at\ time\ t \end{bmatrix}, \quad (2.2)$$

where $j \in \{RE, PJ, SE\}$

Before the age of 80, combinations of paid-job, self-employment, and retirement career alternatives are available for all individuals in each period. The combination of available career choice is K ($K = \{0, 1, 2\}$).[24]

The other discrete choice variable is SSB application (more detailed information about SSB follows in subsection 2.4.5 and Appendix B.2).[25] In general, workers are eligible for applying the benefits from age 62. The eligible agent can choose whether he will apply for the benefit or not. $B_{it} \in \{0, 1\}$ denotes an index function, which has the value one if an agent has applied to the benefit and has the value zero otherwise. The benefits application is an absorbing state, and thus once the application decision has been made, it cannot be reversed.

Continuous choices: In each period t, each person optimally chooses the amount of savings (a_{it+1}) and decides how many hours he will work (h_{it}) conditional on the discrete career choice (k_{it}^{j}). These variables are obtained via splines after using discretizations.

[23]Involuntary unemployment is not considered in this paper, and in each period, every individual receives wage offers explained in subsection 2.4.3 and has a chance to open his own business. With regard to retirement, I define any individual who is not in the labour force as a retired person.

[24]Workers can exit the labour force voluntarily at any time, however, people aged 80 and over are not allowed to work exogenously. Thus, everyone retires at age 80.

[25]It is allowed for individuals to get SSB and work at the same time. However, the amount will be reduced if he begins to draw the benefit earlier than full retirement age or earns more than a certain amount.

2.4.2 Utility and Bequest Function

Individual's within-period utility is defined as his utility from consumption c_{it}, leisure l_{it}, and two unobserved component $\epsilon_{it}(k^j_{it})$ & η_i, associated to the career choice. Within-period utility function for each health status categories hs_{it} ($hs_{it} \in \{Good,\ Fair,\ Bad\}$) is given by:

$$
\begin{aligned}
U(d^j_{it}, z_{it}, \eta_i, \epsilon_{it}, hs_{it}|\theta) = \frac{(c_{it}^{\alpha_{hs_{it}}} l_{it}^{1-\alpha_{hs_{it}}})^{1-\sigma}}{1-\sigma} + \theta_{RV} \times 1_{\{k^j_{it-1}=0\}} \times 1_{\{k^j_{it}\neq 0\}} \\
+ \eta_i \times 1_{\{k^j_{it}=2\}} + \theta_B(age_{it}) \times 1_{\{B_{it-1}=0\}} \times 1_{\{B_{it}=1\}} + \epsilon_{it}(k^j_{it}), \\
\theta_B(age_{it}) = \ \theta^B_0 + \theta^B_1 \times age_{it} + \theta^B_2 \times age^2_{it}, \quad \theta_B = [\theta^B_0, \theta^B_1, \theta^B_2],
\end{aligned}
\tag{2.3}
$$

where $\theta = \{\alpha_{hs_{it}}, \sigma, \theta_{RV}, \eta_i, \theta_{SE}, \theta_P, \theta_{PA}, \theta_B, \theta_{Fair}, \theta_{Bad}, \theta_{BE}, K\}$ is a set of preference parameters, and z_{it} is a set of state variables which will be explained in section 2.4.6. $\alpha_{hs_{it}}$ captures the relative importance of consumption under each health status category hs_{it}.[26] The coefficient of relative risk aversion is given by σ (>0). $1_{\{.\}}$ is an indicator function, which has the value one if an individual's current state corresponds to $\{.\}$ and value zero, otherwise.[27] θ_{RV} captures fixed utility costs caused by returning to the labour force from retirement. The coefficient represents a psychic cost of returning to work and prevents people from excessive entry into and exit from the labour force. η_i is a random parameter, which does not vary over time and is fixed across individuals. The distribution of η_i is assumed to be normal ($\eta_i \sim N(\mu_\eta, \sigma^2_\eta)$). It is assumed that this captures non-pecuniary benefits (NPB) to self-employment, so it represents unobservable heterogeneity across individuals. An individual with relatively high η_i, all else equal, is more likely to become self-employed. For instance, if an agent does not want to work under someone's instructions or has a high preference for flexibility in managing time, he is willing to give up some earnings to enter into or to stay in self-employment. $\theta_B(age_{it})$ captures one-time additional utility costs to draw SSB at age_{it}. It is assumed that people need to pay costs to apply for SSB which include both physical and psychological inconvenience, and the costs can vary with the applicant's age. In general, the older people become or the closer people are to retirement, the smaller the uncertainty individuals will face. Thus, they can design their older age with more confidence, so the costs, especially psychological, may decrease with age. $\epsilon_{it}(k^j_{it})$ is a taste shock associated with the discrete career choice. Following **?**, it

[26]**?** point out that the introduction of health status in the life-cycle model is more realistic to capture the changes in the valuation of consumption and leisure with the health condition. The method of measuring individuals' health status will be presented in section 2.4.4.

[27]For instance, if an individual has a paid-job at period t, $1_{\{k^j_{it}=1\}}$ has the value one.

is assumed that $\epsilon_{it}(m)$ and $\epsilon_{it}(n)$ $(m \neq n)$ are serially independent with Type-1 extreme value distribution. Also, η_i and $\epsilon_{it}(k_{it}^j)$ are known when the individual makes his career choice, however, econometricians cannot observe them.

Individual leisure l_{it} is given by:

$$\begin{aligned} l_{it} =& \overline{L} - h_{it} - \theta_{SE} \times 1_{\{k_{it-1}^j \neq 2\}} \times 1_{\{k_{it}^j = 2\}} - \theta_P \times 1_{\{k_{it}^j \neq 0\}} \\ & - \theta_{PA} \times (age_{it} - 55)^2 \times 1_{\{k_{it}^j \neq 0\}} - \theta_{Fair} \times 1_{\{hs_{it} = Fair\}} - \theta_{Bad} \times 1_{\{hs_{it} = Bad\}}, \end{aligned} \tag{2.4}$$

where $\overline{L}$ is time-endowment, and h_{it} is hours of work. θ_{SE} captures the additional fixed cost of opening a new business measured in hours of work per year. This parameter represents a diverse kind of constraints, including the cost of creating a new business, *ex-ante* psychological costs about starting a business, and initial additional efforts.[28] I assume that even if an individual has had the experience of running a business in the past, once he goes out of his business, he has to pay this cost again for re-entry.[29] This parameter plays a role in limiting excessively frequent entry and exit decisions of the business they create. θ_P denotes fixed costs of working. In order to participate in the labour force, all people pay this utility cost regardless of age. θ_{PA} measures additional participation costs explained by age. θ_{Fair} and θ_{Bad} are the additional participation costs caused by having 'Fair' or 'Bad' health, respectively.

Following **?**, I assume that individuals derive utility from asset bequests, and thus the bequest function has the following functional form:

$$b_{it} = b(a_{it}) = \theta_{BE} \frac{(a_{it} + K)^{\alpha_{hs_{it}}(1-\sigma)}}{1-\sigma} \tag{2.5}$$

where a_{it} is the amount of bequest, θ_{BE} is bequest shifter, and K determines the curvature of the bequest function. If $K = 0$, there is an infinite dis-utility of leaving non-positive bequest.

2.4.3 Wage Equation

The logarithm of the hourly wage in the paid- and self-employment sector is a function of time-invariant sector-specific ability, age, health status, work experience and error components.

[28]In this paper, I do not consider the amount of start-up capital. However, following the U.S. Bureau of the Census (1997), 57% of small business require less than \$5,000 of start-up capital.

[29]*i.e.* Except for the case that an individual already has run his business at time t-1, individuals who want to enter into self-employment at time t should pay θ_{SE}.

Sector-specific work experience: It is assumed that if an agent changes his sector, regardless of his past experience in the sector, his sector-specific experience is initialized, and thus he should newly build up work experience in the new sector. However, if an individual does not change his sector, his experience in the sector will be increased by one year at the end of each period.

$$x_{it}^{j} = \begin{bmatrix} x_{it-1}^{j} + 1 & if\ k_{it}^{j} = k_{it-1}^{j} \\ 1 & if\ k_{it}^{j} \neq k_{it-1}^{j}\ and\ k_{it}^{j} \neq 0 \end{bmatrix} \tag{2.6}$$

In particular, equation (2.6) implies that regardless of previous management (paid-sector) experience, individuals who re-open their own business (return to paid-job) should accumulate self-employment (paid-employment) experience again from zero-year.[30] Although it would be a very restrictive assumption, it may be justified in two ways: (1) among individuals who entered self-employment in the HRS, only a limited proportion of people (11.0%) opened their own business two times or more, and (2) the actual hourly wage distribution of self-employed who tried self-employment just once is similar to that of individuals who attempted it twice or more (figure 2.5(b)). Therefore, the effect of the assumption on individuals' career choice would be limited.

Paid-employment: If an individual chooses the paid-sector, his hourly wage rate depends on the individual's fixed earnings ability in the paid-sector f_i, deterministic productivity component $G_{PJ}(X_{it}^{PJ})$, whether working less than 1,500 hours per year, and an AR(1) persistent error component v_{it}. The log wage equation is given as:[31]

$$ln\ w_{it}^{PJ} = \Big(f_i + G_{PJ}(X_{it}^{PJ})\Big) \times (1 - \varsigma \times 1_{\{h_{it} \leq 1{,}500\}}) + v_{it} \tag{2.7}$$
$$f_i \sim N(\mu_f, \sigma_f^2), \quad X_{it}^{PJ} = \{age_{it}, x_{it}^{PJ}, hs_{it}\}, \quad v_{it} = \rho_{AR} v_{it-1} + \xi_{it}, \quad \xi_{it} \sim N(0, \sigma_\xi^2),$$

where $G_{PJ}(X_{it}^{PJ})$ is the deterministic common part of paid-job wage which is the function of paid-sector specific work experience (x_{it}^{PJ}), age, and health status. The individual's time-invariant earnings ability in the paid-sector is drawn from a normal distribution, and through past experience of life, he has sufficient information to know about his own ability without any uncertainty at the time he chooses a career choice. The parameter ς captures wage penalty and represents a decrease in wages

[30] In particular, individuals who go out of business completely forget about the signal that they receive through running their own business (This is explained in the self-employment wage equation part).

[31] Appendix B.1 provides a detailed description of paid- and self-employment wage equations.

associated with working as a part-timer.[32] If an elderly worker having a full-time job wants to enjoy more leisure (*i.e.* work less than 1,500 hours) and does not choose self-employment, there exists trade-off between enjoying more leisure and a relatively high expected wage.[33] It is an important difference between paid- and self-employment sector (this will be explained below). The persistent error shock consisted of correlation component ρ_{AR} and innovation ξ_{it} also affects an individual's career choice. In reality, a relatively small proportion of people who retire from the labour force or move to self-employment returns to the paid-sector again, so in order to match the transition across sectors or move-in and -out of the labour force properly, it is assumed that if he is not in paid-sector, v_{it} is depreciated with the rate of ρ_{AR}.

Self-employment: The hourly wage rate of self-employed is described by:

$$ln\ w_{it}^{SE} = \varphi_i + G_{SE}(X_{it}^{SE}) + \psi_{it} \tag{2.8}$$
$$\varphi_i \sim N(\mu_\varphi, \sigma_\varphi^2), \quad X_{it}^{SE} = \{age_{it}, x_{it}^{SE}, hs_{it}\}, \quad \psi_{it} \sim N(0, \sigma_\psi^2), \quad Corr(\varphi_i, f_i) = \rho,$$

where $G_{SE}(X_{it}^{SE})$ is a deterministic function of age, self-employment sector-specific work experience x_{it}^{SE}, and health status. Compared with the paid-sector, there are two evident characteristics in self-employment earnings. One is that although f_i is known surely, people entering self-employment are assumed to just know the distribution of their managerial ability φ_i. I assume that f_i and φ_i are correlated ρ and follow a bivariate normal distribution.[34] Thus, before entering self-employment, agents form a belief in their entrepreneurial ability based on known information. Once an individual opens his own business and accumulates experience as self-employed, it allows him to refine his belief in φ_i. However, even if self-employed run their own business, they cannot directly observe φ_i but just can observe a noise signal.[35] The other is that self-employment wage does not have a persistent stochastic element and just has idiosyncratic transitory shock ψ_{it}. The assumption is partly for computational convenience. However, in some way, a persistent shock

[32] An individual is regarded as a full-time worker if he works more than 1,500 hours per-year. An individual is categorized as a part-timer if he works equal to or less than 1,500 hours.

[33] *i.e.* In order to enjoy more leisure in the paid-sector, he faces a considerable amount of wage loss.

[34] $[f_i, \varphi_i] \sim N\left(\begin{bmatrix} \mu_f \\ \mu_\varphi \end{bmatrix}, \begin{bmatrix} \sigma_f^2 & \rho\sigma_f\sigma_\varphi \\ \rho\sigma_f\sigma_\varphi & \sigma_\varphi^2 \end{bmatrix}\right)$, and this distributional information is common knowledge for all individuals.

[35] Individuals cannot differentiate their managerial ability separately from productivity shock. Thus, they cannot confirm how much of their earnings is due to their inborn ability in self-employment. Put somewhat differently, individuals just can observe a signal ($ln\ w_{it}^{SE} - G_{SE}(X_{SE,it})$).

reflects employment shocks in the paid-sector. For instance, a large productivity shock can be observed in the paid-sector when an agent changes employer or occupation voluntarily or involuntarily.

Bayesian learning: It is assumed that self-employed use Bayesian rules for updating belief in their managerial ability with accumulating business experience. If an individual newly ventures a business, his conditional initial (priori) belief on the entrepreneurial ability φ_{i0} is;

$$\varphi_{i0} \sim N(\mu_{\varphi_{i0}}, \sigma^2_{\varphi_0}), \quad \mu_{\varphi_{i0}} = \mu_\varphi + \frac{\sigma_\varphi}{\sigma_f}\rho(f_i - \mu_f), \quad \sigma^2_{\varphi_0} = \sigma^2_\varphi(1-\rho^2) \tag{2.9}$$

Equation (2.9) shows that ρ affects the expected returns to entering entrepreneurship. As the correlation of earnings abilities in the two-sector increases, expected earnings of entrepreneurs with relatively high paid-sector ability rise, and individuals have a higher degree of certainty about ex-ante entrepreneurial earnings. For instance, if two abilities are perfectly independent ($\rho = 0$), the expected value of *ex-ante* (zero-year) managerial skills and its uncertainty just depends on the distribution of managerial ability in the economy ($i.e.$ $\varphi_{i0} = \varphi_i \sim N(\mu_\varphi, \sigma^2_\varphi)$). However, if ρ approaches 1 (-1), workers who have outstanding abilities in the paid-sector certainly can show their excellence (inferiority) in running their own business, and at the same time uncertainty about their ability dissipates quickly.

As an individual accumulates consecutive years of management experience, he can update his belief using Bayes' rule and partly reduce initial uncertainty about his entrepreneurial ability.[36] This yields;

$$\begin{aligned} &\varphi_{i,x^{SE}_{it}} \sim N(\mu_{\varphi_{i,x^{SE}_{it}}}, \sigma^2_{\varphi_{i,x^{SE}_{it}}}), \\ &\mu_{\varphi_{i,x^{SE}_{it}}} = \frac{\sigma^2_\psi \mu_{\varphi_{i0}} + x^{SE}_{it}\sigma^2_{\varphi 0}\overline{R_{it-1}}}{x^{SE}_{it}\sigma^2_{\varphi 0} + \sigma^2_\psi}, \ \sigma^2_{\varphi_{i,x^{SE}_{it}}} = \frac{\sigma^2_{\varphi 0} \times \sigma^2_\psi}{x^{SE}_{it}\sigma^2_{\varphi 0} + \sigma^2_\psi}, \end{aligned} \tag{2.10}$$

where $\overline{R_{it}}$ is the mean of the residual log-earnings history in the self-employment sector from zero-year experience level to x^{SE}_{it}, net of the deterministic profile in self-employment.[37] Thus, Equation (2.10) implies that the accumulation of management experience allows self-employed to partially differentiate how much earnings change is caused by transitory idiosyncratic shock with more confidence and to partly

[36] As he observes his realized earnings, he updates and changes a belief about the distribution of his managerial ability. Following **?**, the information updating structure in this study is 'partially observed and correlated'.

[37] The residual log-earnings R_{it} is denoted by: $R_{it} = ln\ w^{SE}_{it} - G_{SE}(X^{SE}_{it}) = \varphi_i + \psi_{it}$

reduce initial uncertainty about their entrepreneurial ability (having more precise information and reducing uncertainty on their managerial ability).[38]

2.4.4 Health Status Transition and Medical Expenses

Health status affects (1) the amount of medical expenditure, (2) survival probabilities, (3) productivity, (4) the relative importance between consumption and leisure, (5) leisure time, and (6) spouse's LFP. However, unfortunately, it is impossible to directly observe the actual health status, and only objective and subjective measures of health conditions are available. Despite the growing research on the effect of health on labour force decisions, it is still debatable how to measure it. This study follows the method suggested by **?**. I use Principal Components Analysis (PCA) and combine multiple subjective measures of health status (self-reported health, health limits work, and activity of daily living-summary) into one single index hs_{it}. Although this method cannot rule out measurement errors completely, it is not only a parsimonious method but also mitigating the problems. In any given period, an individual's current health status can be Good, Fair or Bad (*i.e.* $hs_{it} \in \{Good, Fair, Bad\}$). hs_{it} evolves stochastically to hs_{it+1} having values Good, Fair, Bad, or Dead (Henceforth, I assign the value 0 to an individual with 'Good' health, 1 to 'Fair', 2 to 'Bad', and 3 to a 'Dead' person ($hs_{it+1} \in \{0, 1, 2, 3\}$)).

The probability of given health to next period health state depends on the individual's age (including squared age) and current health state. It is assumed that transition probabilities from one to another state are given exogenously, so individuals cannot affect the probability through investment in health or increase in hours of exercise.[39] The health transition probabilities are estimated by ordered logistic regression.

$$pr(hs_{it+1}|age_{it}, hs_{it}) = \Lambda(hs_{it+1}|age_{it}, hs_{it}) \tag{2.11}$$

Medical expenses m_{it} are defined as out-of-pocket costs in this model. The costs are assumed as a negative income shock which should be paid in order to survive to the next period, however, the costs have no impact on future medical expenses or health status.[40] Medical expenses are modelled as the function of an individual's age age_{it}, asset holdings a_{it}, obtaining a qualification in Medicare $1_{\{Medicare_{it}\}}$, and

[38] *i.e.* As x_{it}^{SE} goes to infinity, $\mu_{\varphi_{i,x_{it}^{SE}}}$ converges asymptotically to φ_i, and $\sigma^2_{\varphi_{i,x_{it}^{SE}}}$ monotonically decreases.

[39] A bunch of research such as **???** introduces similar exogeneity assumption.

[40] It is assumed that individuals have to make career and labour supply decisions before observing m_{it} for the period. However, using known information, they form expectation on the costs ($E(m_{it})$).

health state hs_{it} as follows:[41]

$$ln\ m_{it} = M(age_{it}, a_{it}, 1_{\{Medicare_{it}\}}, hs_{it}) + u_{it}, \quad u_{it} \sim N(0, \sigma_u^2), \tag{2.12}$$

where $1_{\{Medicare_{it}\}}$ has the value one if the individual's age is equal or over 66 and has the value zero otherwise.

2.4.5 Budget Constraint

Each individual has five different sources of income: asset income ra_{it}, own labour income $w_{it}h_{it}$, social security retired worker benefits ssb_{it}, spouse's income w_{it}^{si} and government transfer Tr_{it}. Resources are allocated between household consumption, saving and medical expenditures m_{it}. The budget set is written as:

$$\begin{aligned} c_{it} + a_{it+1} = a_{it} + Y(ra_{it}, w_{it}^{j}h_{it}, B_{it-1} \times ssb_{it}, \tau) + w_{it}^{si} \times 1_{\{LFP_{it}^{s}=1\}} \\ + Tr_{it} - m_{it}, \end{aligned} \tag{2.13}$$

where r is the real interest rate, and τ denotes tax structure.

Spousal income: Considering the fact that the spouse's expected income si_{it} can serve as insurance against diverse kinds of shocks, the spouse's earned income is required to be included in the model. However, the consideration of joint labour supply and retirement choices between the couples would impose great computational burdens. Also, on average, 37.4% of wives aged 51-79 participate in the labour force, and their LFP rate rapidly decreases with age.[42]

Thus, in order to reflect distinctive characteristics of married women's LFP and minimize the complexity, it is assumed that the wife's decision on her each period LFP is randomly drawn at the end of the period (*i.e.* after her husband makes the labour force and savings choices). In particular, considering the rapid decline in the spouses' LFP with age, the wife's participation probability p_{it}^{s} is determined by her age age_{it}^{s}, husband's health condition, and the expected amount of medical expenses.[43] In addition, for reducing computational burdens, I assume that her earned income w_{it}^{si} is a function of deterministic variables (her age and husband's

[41] Age, squared and cubic age are used. It is assumed that there is a correlation between wealth and the quality of care that individuals choose, and all individuals are qualified to Medicare at age 66. Appendix B.1 provides a detailed description of the functional form of medical costs.

[42] Similar to husband, wife's LFP rate in the sample declines rapidly with age. It decreases from 73.3% at age 51 to 4.7% at age 79.

[43] In the sample, if a husband's health status is good, fair or bad, the wife's average LFP rate is 44%, 33%, and 28%, respectively.

health status as well as fixed ability in the paid-sector), and the related parameters are estimated external to the structure model.[44]

$$E_t(si_{it}) = E(si_{it}|age^s_{it}, hs_{it}, f_i) = p^s_{it}\,(age^s_{it}, hs_{it}, E_t(ln\ m_{it})) \times w^{si}_{it}(age^s_{it}, f_i) \quad (2.14)$$

Social Security Retired Worker Benefit (SSB): Social Security generates a potentially important effect on elderly people's work and retirement choice, and it usually causes a negative effect on work incentives after a certain age. Once a worker has claimed SSB, he will receive the benefit for life. The amount of ssb_{it} depends on many factors such as a worker's lifetime earnings, the choice of time for first claiming benefit, and employment decisions.

To be eligible for SSB, an individual needs at least 10 years of Social Security covered employment. If an individual has worked less than 35 years, an additional year of work increases his SSB. However, if he already has worked 35 years or more, SSB is adjusted only if his earnings from an additional year of work are higher than the lowest earnings included in his current average indexed monthly earnings (AIME). Considering the fact that only 5.6% of individuals in the sample have less than 10 years of work history, and around 65% of individuals have worked more than 35 years at age 62, it is assumed that every individual is eligible for SSB and has already worked 35 years or more. Also, although the earliest age when an agent can claim SSB is at age 62, the benefit will be permanently reduced if she draws the benefits before the Full Retirement Age (FRA). The FRA has been gradually increased from age 65 in 2002 to 67 in 2027, so I use age 66 as the FRA. Workers who begin to draw the benefits after the FRA receive delayed benefits. If an individual starts to draw the benefit before age 66, I assume that the benefit is reduced by 6.7% every year. Also, delayed benefit claiming leads to an increase in benefits by 7.0% every year. Detail of SSB structure is described in Appendix B.2.

Tax structure: The tax rates and exemption amounts used in this study are the figures in 2000. The tax system τ is composed of payroll tax τ^P, federal tax τ^F and taxes on SSB τ^{SSB}. Payroll tax is levied on the wages and net self-employment income. The tax is levied at a rate of 15.3% which is divided into two components: Social Security tax 12.4% and Medicare tax 2.9%. The only difference between paid-workers and self-employed is that self-employed have to bear these taxes on their own, however, half of the taxes on paid-job earnings are shared by employers. Thus, the effective payroll tax rate for employees is 7.65% of earnings up to the upper limit of $76,200. Since 1984, SSB have been subject to federal income tax. Up

[44] The detailed functional form of a spousal income is described in Appendix B.1.

to 50% and 85% of SSB are taxable for single taxpayers whose provisional income (PI) exceeds \$25,000, and \$34,000, respectively. With regard to Federal Income tax, it is levied on labour and non-labour income. I use the Federal Income Tax tables for "Single Tax Bracket". Appendix B.3 provides a detailed description of the U.S. tax structure.

Transfer programs: The government runs transfer programs that guarantee a minimum level of resources c_{min} for individuals in every period. For instance, in the U.S., the Supplemental Security Income Programme provides income support. When households' disposable income is lower than c_{min}, the government provides a certain amount of resources. Following **?**, the government transfers that an individual receives are given by:

$$Tr_{it} = min\{c_{min}, max\{0, c_{min} - [(1+r)a_{it} + (1-\tau^P)w^j_{it}h_{it} \times 1_{\{k^j_{it} \neq 0\}} + ssb_{it}]\}\} \tag{2.15}$$

2.4.6 State Variables

The state space in period t consists of variables that are observed both by the agent and econometricians and variables that are only observed by the agent, but not by econometricians ($\epsilon_{it}(k^j_{it})$ and η_i). Optimal decisions depend on the state variables z_t, determinants of each sectoral earnings process β^{PJ} & β^{SE}, preferences θ, and the parameters that determine the data generating process χ for the state variables:

$$z_{it} = \{a_{it}, AIME_{it}, k^j_{it}, x^{PJ}_{it}, x^{SE}_{it}, age_{it}, v_{it-1}, \overline{ln(R_{it-1})}, B_{it-1}, f_i, \varphi_i\} \tag{2.16}$$

$$\beta^{PJ} = \{\beta^{PJ}_0, \beta^{PJ}_1, \beta^{PJ}_2, \beta^{PJ}_3, \beta^{PJ}_4, \mu_f, \sigma^2_f, \rho_{AR}, \sigma^2_\xi\} \tag{2.17}$$

$$\beta^{SE} = \{\beta^{SE}_0, \beta^{SE}_1, \beta^{SE}_2, \beta^{SE}_3, \beta^{SE}_4, \mu_\varphi, \sigma^2_\varphi, \sigma^2_\psi, \rho\} \tag{2.18}$$

$$\theta = \{\alpha_{Good}, \alpha_{Fair}, \alpha_{Bad}, \sigma, \beta, \eta_i, \theta_B, \theta_P, \theta_{PA}, \theta_{RV}, \theta_{Fair}, \theta_{Bad}, K, \theta_{SE}, \theta_{BE}\} \tag{2.19}$$

$$\chi = \{G_{PJ}(X^{PJ}_{it}), G_{SE}(X^{SE}_{it}), M_{it}, \Lambda_{it}, s_{it}, c_{min}, \tau\} \tag{2.20}$$

2.4.7 Model Solution

The problem is a finite-horizon discrete choice, the feasible set of individual choices is compact, and the function is continuous, so the value function always exists and has a unique solution to the Bellman equation.

$$\begin{aligned} V_{it}(z_{it},\eta_i,\epsilon_{it},\theta) &= max_{d^j_{it}} U(d^j_{it}, z_{it}, \epsilon_{it}, \eta_i, \theta) \\ &+ \beta E_t \left[V_{it+1}(z_{it+1}, \epsilon_{it+1}, \theta | z_{it}, d^j_{it}, \eta_i) \right] \\ &+ pr(hs_{it+1} = 3 | hs_{it}, age_{it}) \times E_t \left[b(A_{it+1}) \right] \end{aligned} \tag{2.21}$$

$$\begin{aligned} E_t V_{it+1} &= \Sigma^2_{m=0} pr(hs_{it+1} = m | hs_{it}, age_{it}) \\ &\times \int \int V_{it+1}(z_{it+1}, \epsilon_{it+1}, \theta) g(\epsilon_{it+1}) f(z_{it+1}|z_{it}, d^j_{it}, \eta_i) d\epsilon_{it+1} dz_{it+1}, \end{aligned} \tag{2.22}$$

where $f(z_{it+1}|z_{it}, d^j_{it}, \eta_i)$ is the transition density function which decides the evolution of the observed state variables, and $pr(hs_{it+1} = 3|hs_{it}, age_{it})$ is conditional probability of death between age t and t+1.[45] $\epsilon_{it}(k^j_{it})$ is a vector of taste shock associated to the discrete career alternative, and it is drawn from distribution $g(\epsilon_{it})$. It is assumed that the functional form of the $g(\epsilon_{it})$ follows type-1 extreme value which is independently identically distributed across individuals and over time, and non-pecuniary benefit follows normal distribution ($\eta_i \sim N(\mu_\eta, \sigma^2_\eta)$).

Ex-ante value function is defined by $\overline{V_{it}}(z_{it}, \eta_i, \theta)$ as the continuation value of being in state z_{it} just before ϵ_{it} is revealed. Thus, $\overline{V_{it}}$ is given by integrating $V_{it}(z_{it}, \eta_i, \epsilon_{it}, \theta)$ over ϵ_{it}:

$$\overline{V_{it}}(z_{it}, \eta_i, \theta) \equiv \int V_{it}(z_{it}, \eta_i, \epsilon_{it}, \theta) g(\epsilon_{it}) d\epsilon_{it} \tag{2.23}$$

With the future value term and η_i in hand, the conditional value function is defined by $\nu_{it}(z_{it}, d^{j'}_{it}, \eta_i, \theta)$ as the present discounted value of choosing specific career j' ($d^{j'}_{it} = [j', a_{it+1}, h_{it}, B_{it}]$):

$$\nu_{it}(z_{it}, d^{j'}_{it}, \eta_i, \theta) = max_{d_{it}(-j')} \left[u(z_{it}, d^{j'}_{it}, \theta) + \eta_i + \beta \int \overline{V_{it+1}}(z_{it+1}, \theta) F(z_{it+1}) \right] \tag{2.24}$$

An individual's optimal decision rules (d^j_{it}) can be computed in two stages: Firstly, optimal savings, hours of work and SSB application decision are computed conditional on each discrete career alternative (inner maximization, equation (2.24)).[46] $d_{it}(-j')$ denotes a vector of choice variables given the LFP mode $j = j'$ ($k^j_{it} = k^{j'}_{it}$, $d_{it}(-j') = d^{j'}_{it} \sim \{k^j_{it} = k^{j'}_{it}\}$). Second, the discrete option that yields the

[45] For the notational simplicity, $f(z_{it+1}|z_{it}, d^j_{it}, \eta_i)dz_{t+1}$ is denoted by $F(z_{it+1})$ henceforth. $pr(hs_{it+1} = 3|hs_{it}, age_{it}) = 1 - \Sigma^{m=2}_{m=0} pr(hs_{it+1} = m|hs_{it}, age_{it})$. Individuals live at most until age 100. Therefore, all agents surely die before they reach at age 101.

[46] For notational simplicity, the age-dependent cost of claiming the SSB ($\theta_B(age_{it})$) is excluded in the equation.

highest value given the draw of the unobservable state is chosen by the individual (outer maximization, equation (2.25)).

$$\delta_{it}(z_{it}, \epsilon_{it}, \theta) = argmax_{k^j_{it}} [\nu_{it}(z_{it}, k^j_{it}, \eta_i, \theta) + \epsilon_{it}] \tag{2.25}$$

Following the distributional assumption on ϵ_{it}, the probability of choosing an arbitrary career (k^*_{it}) and the *ex-ante* value function are given by:

$$p(k^*_{it}|z_{it}, \eta_i, \theta) = \frac{exp\left(\nu_{it}(z_{it}, d^*_{it}, \eta_i, \theta)\right)}{\Sigma_{k^j_{it} \in K} exp\left(\nu_{it}(z_{it}, d^j_{it}, \eta_i, \theta)\right)}, \tag{2.26}$$

$$\begin{aligned}\overline{V_{it}}(z_{it}, \eta_i, \theta) &= ln\left(\Sigma_{k^j_{it} \in K} exp[\nu_{it}(z_{it}, d^{j'}_{it}, \eta_i, \theta)]\right) + \gamma \\ &= \nu_{it}(z_{it}, d^*_{it}, \eta_i, \theta) + \gamma - ln[p(k^*_{it}|z_{it}, \eta_i, \theta)],\end{aligned} \tag{2.27}$$

where γ denotes Euler's constant, and d^*_{it} is arbitrarily selected choice ($j = *$).

The last equality in equation (2.27) has an intuitive interpretation: the *ex-ante* value of being in the state z_{it} can be expressed as a sum of the conditional value from making an arbitrary choice k^*_{it}, Euler's constant, and a non-negative adjustment term which adjusts for the fact that k^*_{it} may not be the optimal choice.

2.5 Identification and Estimation Strategy

Given the model specification, the vector of parameters in this study is divided into three categories. First, some parameters are taken from outside. For the purpose of compatibility with other literature, the discount factor β is set to 0.96, and the national wage growth rate g_w is considered to have a value of 4.0%.[47] Also, it is assumed that an annualized pre-tax real rate of return r is 4.0%.[48] The second set of parameters is estimated external to the structural model. The medical costs, health status transition, and spousal income are included in this category and estimated directly from the data. Finally, given the first and second sets of parameters, the parameters of utility function along with consumption floor c_{min} and earnings process are estimated by matching moment conditions.

2.5.1 Identification of Model Parameters

This study estimates preference and earnings parameters simultaneously. The identification argument of θ is standard and depends on savings and sector choices

[47] In order to reflect the overall real wage growth rate in the economy, AIME is adjusted at the rate of 4.0% before the age of 60.

[48] **?** find that the real rate of return for equity in the U.S. is around 4%, over the last 100 years.

of individuals who face different constraints across sectors. With regard to the earnings process, if β^{PJ} and β^{SE} are estimated on just the labour force participants, these cause an important threat to estimate the work and retirement choice. The data show the existence of strong selection issue with respect to the health status and age, and if the earnings profiles are directly identified from actual wages just including observations for workers, potential wage rates of retirees cannot be used to estimate parameters. Thus, estimation methods using actual wage profiles cannot properly control a selection-problem as the elderly leaves the labour force with age.

Moreover, additional difficulties arise on the consideration of sector choices. Individuals who choose a different sector may not be a random sample from the entire population, and thus the selection-problem may be plagued by the fact that occupation changes may occur to a self-selected group with regard to unobservable characteristics. Thus, the use of wages, which are already sorted into a particular sector, potentially introduces the bias resulting from self-selection and causes an important threat to analyse occupational choice.[49] In order to control the selection issue, the model explicitly considers selection across sectors conditional on preference, the amount of asset holdings, sectoral differences in earnings and flexibility, and health conditions. Also, entering into and exit from self-employment would be correlated with the paid-sector ability, so the sectoral abilities are identified based on the assumption that the paid- and self-employment sector abilities follow a bivariate normal distribution with correlation. In addition, the difference in effective payroll tax rates levied on paid-sector and self-employment earnings may play a role as an additional exclusion restriction. Although the government levies the same tax rate across sectors, half of the paid-workers' payroll tax is shared by employers, so it is correlated with sector choices and uncorrelated with earnings. Thus, these tax incentives act as another exclusion restriction, which allows for controlling the bias in earnings estimates.

2.5.2 Estimation Methodology and Initial Conditions

The parameters are estimated by the Method of Simulated Moments (MSM) strategy which fits the life-cycle profiles derived from the HRS to the predictions of the model for drawn typical 50,000 households aged 56-90. The estimated parameters minimize the sum of squared differences between the selected moment conditions in the data and their counterparts derived from simulated individuals. To do this, the observed individuals' career choice, hours of work, asset-holdings, SSB-application,

[49] *i.e.* Incomes are only observed in the sectors that individuals choose to work.

and earnings are used to derive the vector of unknown preference parameters. In order to estimate these parameters, the following 211 empirical moments are used:

- By age, the relative fraction of individuals who have a paid-job and run their own business for the age group 56-79 (48)
- By age, mean hours of work for the labour force participants for the age group 56-79 (24)
- By age, asset accumulation for age group 56-90 (35)
- By age, the relative portion of individuals who apply Social Security Retired Worker Benefit for the age group 62-69 (8)
- By age, the paths of the average wage and its standard deviation profiles in paid- and self-employment sectors for the age group 56-79 (96)

The initial conditions are drawn from the empirical joint distribution of assets, life-time earnings history (AIME), and the mean of the residual log-earnings for individuals aged 56-60. In particular, as the career change initializes sector-specific work experience, individuals whose work experience in one-sector is greater than zero need to have zero-experience in the other sector. However, in order to explain career choice at the initial model period (at age 56), individuals are randomly assigned work experience in both sectors as an initial condition of work experience. Given their paid-job as well as self-employment experience at age 56, preference, and other initial conditions, individuals choose their career. After they choose a career in the initial model period, sector-specific work experience follows the given work experience accumulation rule. Once the preference and earnings parameters are estimated, I then solve the model household-by-household.

2.6 Parameter Estimates and Model Fits

2.6.1 Preference Parameter Estimates

The preference parameter estimates are presented in table 2.5. The first three rows of the table show the utility weight on consumption that differs across health status. Individuals with a high value of $\alpha_{hs_{it}}$ have a stronger preference for work. Due to the additional fixed cost caused by having 'Fair' or 'Bad' health, people who are not in 'Good' health need to have stronger labour force attachment to participate in the labour force. The estimated relative risk aversion (RRA) for the consumption of people with 'Good' health is 4.0428 ($\sigma = 6.6907$).[50] Although the estimated RRA

[50]The relative risk aversion for consumption can be approximated as $-\frac{(\partial^2 U/\partial C^2)C}{\partial U/\partial C} = 1 - \alpha_{hs_{it}}(1-\sigma)$. The estimated RRA of people with "Fair" and "Bad" health is 4.1839 and 4.2710, respectively

in this study is larger than the reported values of 1.0-1.8 by **?**, it falls within the range 2.2-5.1 by **?**.

The estimate of the minimum level of resources (c_{min}) is \$8,996 which is equivalent to the Federal SSI benefit for elderly couples aged 65 or over (\$9,000, Committee on Ways and Means 2000). The estimate of leisure endowment ($\overline{L}$) is 5,805 hours and the fixed cost of LFP (θ_P) is 742 hours per year. Figure 2.6a shows the additional participation cost associated with age ($\theta_{PA} \times (age_{it} - 55)^2$). For instance, the fixed additional cost of work at age 60 is 40 hours per year, and it becomes 358 hours at age 70. The estimated time cost of opening a new business (θ_{SE}), fair (θ_{Fair}) and bad (θ_{Bad}) health are 356, 552, and 1,029 hours per year, respectively. The bequest parameters θ_{BE} and curvature K are 0.024 and \$5,327, respectively.

Rows 14-19 of the table show estimates of utility parameters. These parameters are not interpretable readily. The estimated fixed cost of returning to work from retirement θ_{RV} is -0.0093. This implies that once an individual leaves the labour force, considerable disutility should be endured to get back to work (entrance cost to return to the labour force again). The estimated value of θ_B implies that the cost of applying SSB is decreasing with age, and it adequately reflects the growing number of people who decide to draw SSB as they get older.

Regarding the non-pecuniary benefits (NPB) parameters, the estimated mean (μ_η) and variance (σ_η^2) are $\eta_i \sim N(-0.00010, 0.009462^2)$. The estimated values imply that 49.2% of elderly men receive a positive utility from self-employment. This figure is higher than the reported value of 15% by **?**. However, considering the fact that their sample includes men between the ages 22-55, and the self-employment rate of the elderly is 2.5 to 4.2 times higher than that of the youth (figure 2.1(a)), the difference would be acceptable. NPB captures an individual's preference for self-employment relative to paid-employment. Thus, the negative sign of μ_η implies that, in order for an individual to enter self-employment, their expected returns should be higher than earnings, which can be earned if the person chooses a paid-sector. However, if an individual has a strong preference for flexibility or puts great importance on becoming his own boss, NPB has a positive sign, and he is willing to give up some money to enter into self-employment.[51]

2.6.2 Earnings Process Parameter Estimates

The estimates of the earnings process in paid-job (full-time) and self-employment are given in table 2.6. As an individual accumulates an additional one more year of paid-

[51] *i.e.* Some individuals with very high η_i run their own business not because they do well but because they just love it.

sector experience, earnings in the sector increase by 0.68% on average. Self-employed earnings also rise in line with the accumulation of business experience. However, they do not increase as rapidly as paid-earnings. As self-employed accumulate ten years of consecutive entrepreneurial experience, their hourly wage rate is 3.7% higher than that of new entrants in self-employment. The parameters on health status $1_{\{hs_{it}=\cdot\}}$ show that relatively poor health status is associated with considerable income loss. Having 'Fair' or 'Bad' health in the paid-sector are associated with a 19.6% and 31.6% reduction in the paid-sector hourly wage. The reductions in wages of self-employed with 'Fair' or 'Bad' health status equal to 10.0% and 15.2%, respectively. In addition, if an individual works as a part-timer, his hourly wage rate is 65.8% ($\varsigma = 0.342$) of the potential wage which the individual can earn if he has a full-time job.

Due to the high variance in self-employment earnings, the entrepreneurial ability is more than 1.5 times as dispersed as paid-sector ability ($\sigma_\varphi = 0.872$ and $\sigma_f = 0.572$). However, abilities in these two-sectors are closely related, so individuals' belief in the variance of managerial ability is smaller than that of the population variance. The estimated correlation between paid- and self-employment ability is $\rho = 0.524$, and thus the variance of prior-belief on entrepreneurial ability $\left(\sigma_\varphi^2(1-\rho^2)\right)$ is 0.552. It means that, despite higher uncertainty in self-employment, the paid-sector ability known for sure can be a good proxy of the chances of success in self-employment. Also, once an agent enters, the uncertainty about his managerial ability declines rapidly. For example, after observing one-year earnings in self-employment, the variance of posterior belief on managerial ability becomes just 28% (0.152) of the variance of prior belief. It drops to 0.020 after 10 years of consecutive accumulation of work experience in self-employment (figure 2.6b).[52]

2.6.3 Model Fit

This subsection evaluates the model's ability to replicate older workers' patterns of behaviour over the life-cycle. Figure 2.7 compares the simulated life-cycle profiles with those of the actual data. The simulated profiles for the age group 57-79 are the paths of average behaviour here and elsewhere in this study.[53] On the whole, the model does a good performance in generating the rich patterns of individuals'

[52]The derived results are compatible with estimates suggested by **?**. They report that the variance of prior belief on the individual's managerial ability is 0.32. The variance of a worker's posterior belief on managerial ability drops to 0.07 after accumulating one year of self-employment experience and 0.02 after five years.

[53]Although there is no compulsory retirement age in the U.S, this study assumes that every agent is forced to stop working at the end of age 79. Moreover, due to the initial conditions on sector-specific work experience at age 56, the age-group for the main analysis is set 57-79.

behaviour over the life-cycle with reasonable parameter estimates. Panel (a) shows that the model well captures individuals' LFP choice. Although it underpredicts the LFP rate between the ages 59 and 62 and the fraction of retired people at ages 75-79, the model closely replicates labour force decisions observed in the entire sample. Looking closer, the proportion of simulated workers in each sector (PJ:29.7% & SE:8.2%) well captures those of the actual sectoral choices (PJ:29.7% & SE:8.3%) on average. Also, although the model overstates asset holdings (panel (d)), it is able to properly replicate other important features such as hourly wage rate (panel (f) and Figure 2.8), SSB application (panel (g)), work hours (panel (e)) and changes in health status (panel (h)).

The model particularly shows a good performance in capturing the distinctive characteristics of self-employment; frequent entry into as well as exit from the business and two prominent peaks on both sides of self-employment spells. Figure 2.9 shows that, on average, 1.4% of simulated individuals newly open their own business, and 1.8% exit self-employment in each period.[54] The actual entry (1.5%) and exit rates (2.1%) are just 0.1%p and 0.3%p higher than those of the simulated individuals, respectively. The entry and exit decisions are also reflected in self-employment sector-specific tenure. Figure 2.10 shows that the model well replicates the self-employment sector job spells skewed to both sides. The model explains the cause of these job tenures as follows: several distinctive characteristics of self-employment incentivise people to run their own business. However, the least successful entrepreneurs who partly realize (or believe) that they do not have the high managerial ability go out of business quickly. At the same time, successful entrepreneurs generating relatively higher returns do not change their career easily and keep their business for a longer period.

In this study, the major forces which lead paid-workers to change their sector are the motivation of enjoying more leisure, having high NPB, relatively high expected earnings, and paid-sector productivity shocks. Also, learning about their managerial ability and transitory productivity shocks cause individuals to go out of business. Comparing the actual transition probabilities with those of the baseline, panel 2 of table 2.7 indicates that the model adequately captures the motivation for individuals to switch their career and qualitatively well describes the transition probabilities. Nevertheless, the factors in this study alone are insufficient to fully capture the transitions observed in the data. The model overpredicts the transition between

[54] In these statistics, the simulated figures not only contain first entry self-employed in their life but also include those who had run their own business in the past and then open it again after they shut down.

paid- and self-employment, however, it still well captures individuals' tendency to choose a specific career; once a path is chosen, people do not easily change it.

2.7 Estimated Life-Cycle Elasticities of Labour Supply

Labour supply elasticities vary much over the life-cycle. As people grow older, worsening health, accumulating more assets, access to SSB, and decrease in productivity cause them to be more elastic on changes in wage. This section explores older people's response to temporary and permanent changes in before-tax wage rates.

2.7.1 Intertemporal Frisch Elasticity of Labour Supply (IFES)

IFES in this study captures both the changes in participation and how the number of hours reacts to transitory changes in the wage rates conditional on holding the marginal utility of wealth approximately unchanged intertemporally. Thus, it is suitable for measuring the response of labour supply between adjacent periods when the wage shock is temporary. Following **?**, the extensive margin is derived by percentage point change in participation when pre-tax wage rates are increased by 1%.[55] The intensive margin of IFES (ϵ_h^{IFES}) can be expressed by:[56,57]

$$\epsilon_h^{IFES} = \frac{dh}{dw}\frac{w}{h}|_{\lambda} = \frac{u_h u_{cc}}{u_{hh}u_{cc} - u_{hc}^2} \times \frac{1}{h_{it}} = \frac{\overline{L} - h_{it}}{h_{it}} \times \left\{\frac{1 - \alpha_{hs_{it}}(1-\sigma)}{\sigma}\right\}, \tag{2.28}$$

where λ_t denotes the marginal utility of wealth in period t (*i.e.* the Lagrange multiplier associated with the budget constraint). The derivation of equation (2.28) assumes the constant marginal utility of wealth ($d\lambda_t = 0$).

The table 2.8 summarizes derived IFES under the assumption that the zero-borrowing constraint does not bind. Column 1-3 provide intensive margin at each age conditional on the participation in the labour force. Numbers in the columns are derived by using the preference parameter estimates and simulated profiles under the baseline. Column 4-6 report extensive elasticity, and the remaining columns show the aggregate response of labour supply. Each row reports the elasticities

[55] This study simulates elderly people's labour force response when hourly before-tax wage rates in both paid- and self-employment sectors are temporally increased by 20% in a particular age and compares it with the baseline. Thus, to convert it into extensive elasticity, the reported participation response is divided by 20.

[56] When ϵ_h^{IFES} is derived, it is assumed that non-binding zero borrowing constraint holds.

[57] If the functional form of per-period utility function is separable in labour and consumption (*i.e.* $u_{ch} = \frac{\partial^2 u}{\partial c \cdot \partial h} = 0$), the equation (2.28) can be expressed by $\frac{u_h}{u_{hh}} \times \frac{1}{h_{it}}$.

when the transitory wage change occurs at age 60, 66, and 70, respectively. The estimated aggregate IFES rapidly increases with age. At age 60, the aggregate elasticity is around 1.06, increasing to 1.43 and 1.81 at age 66, and 70, respectively. Also, comparing it with the extensive elasticity, most part of the labour supply changes caused by an increase in transitory wages is explained by the intensive margin. In other words, temporary changes in wages for people who are near the end of their career mainly induce changes in the distribution of hours of work rather than encouraging more people to participate in the labour force.

Looking closer, as self-employed enjoy more flexibility, the IFES in the self-employment sector evaluated at age 60 has a value of 1.15 which is around 11% higher than that of paid-workers (1.04). The estimated contribution of intensive margin is broadly inline with previous studies which show that the estimated IFES among the elderly is larger than that of prime-age male workers. For instance, **?** use survey evidence and suggest around 1 of IFES. **?** document that it is difficult to rationalize values, which are less than 0.75. **?** show that for temporary wage changes at age 60, the elasticity of hours at age 60 is 1.28. One of the caveats in the estimated IFES is that although individuals in reality as well as in the model face borrowing constraint, the extent of intertemporal hours choice summarized in the table does not reflect it. Thus, the numbers in the table would understate the actual quantities.[58]

2.7.2 Life-Cycle Marshallian Elasticity of Labour Supply

If the wage shocks cause entire changes in life-cycle earnings profiles, the assumption of the constant λ_t would be no longer sustainable. Thus, in order to capture the response of labour supply to permanent wage changes, I use the life-cycle Marshallian elasticity of labour supply (it will be just referred to a Marshallian elasticity henceforth).[59] Table 2.9 reports estimated Marshallian elasticities derived by the comparison between the life-cycle profiles under the baseline and newly simulated labour supply profiles when the pre-tax wage rate is permanently increased by 1% from the age of 60. The first three columns show the results as wages in both sectors are increased at the same rate. Also, for the purpose of capturing sectoral differences in labour supply responses and their interaction effects, column

[58]The binding constraint obstructs individuals' intertemporal optimization which can be achieved by reducing hours of work when they receive negative shocks and force them to work more than desirable. However, without borrowing constraint, negative shocks incentivise people to reduce labour supply and increase borrowing so as to achieve consumption smoothing.

[59]This study follows the Marshallian elasticity suggested by **?**. They refer to the Marshallian elasticities which are allowed for changes in intertemporal savings behaviour as "life-cycle Marshallian elasticity".

4-6 and 7-9 report the elasticities when the change in wages occurs just in paid- and self-employment sector, respectively. Row 1 provides intensive margin which is derived by using simulated individuals who participate in the labour force, and row 2 reports extensive margin derived similar to column 4-6 in table 2.8. The final row reports aggregate elasticities which add both extensive and intensive margins.

The table suggests that both economy-wide average aggregate Marshallian elasticity over the age between 57 and 79 is 0.39. The first column reports that the intensive margin of labour supply for permanent shocks in both sectors is 0.14 which is far lower than that for transitory changes in table 2.8.[60] The result is mainly caused by the fact that although the permanent rise in wages incentivises people to increase their labour supply, the change reduces the motivation of intertemporal reallocation, and the wealth effect from positive income shock would have a greater negative impact on hours and retirement choice. With regard to extensive margin, as people can get higher compensation through the permanent change in wages, the average percentage-point response is 0.25 which implies that workers on the margin of participation are more likely to stay in the labour force rather than choosing retirement. Also, even if the wages in paid- and self-employment sectors are increased at the same proportion, aggregate elasticity for self-employed is around 2.7 times higher than that for paid-one. The difference in elasticity is mainly caused by the fact that an increase in compensation encourages relatively more people who otherwise have a paid-job or remain as a retiree to become his own boss. Also, the contribution of new business entrants' working hours as well as hours choice of incumbents lead to a relatively large increase in intensive margin.

Looking more closely at individuals' responses to permanent wage changes restrictive to a particular sector, there is substantial heterogeneity in the Marshallian elasticity across sectors. Column 4-6 report that the change of compensation limited to paid-sector incentivises more people to stay in paid-job and has a negative effect on the transition between paid-job and self-employment. As fewer people newly become their own boss, it has a relatively strong compositional effect between sectors, and extensive margin in the self-employment sector decreases by 0.18%p.[61] The effect of changes in paid-sector wage on intensive margin is also limited in the paid-sector, and it has a very weak negative or neutral effect on hours of work in the self-employment sector. As a result, the aggregate elasticity for paid-workers is 0.56, and the economy-wide aggregate response is reduced to 0.35 due to the

[60] **?** show that the elasticity of hours for permanent wage changes at age 60 is 0.14 inline with the figure for entire workers in this study.

[61] The rise in the paid-sector wage increase cumulatively increases the proportion of people having paid-job by 8.4%p and decrease the share of self-employed by 3.7%p.

decline in the relative attractiveness of running their own business. However, if the wage increase occurs just in the self-employment sector, it just has a limited effect on the sectoral composition of the mode of participation between paid- and self-employment. Also, as less share of people reaps benefit from the change, the economy-wide aggregate elasticity is 0.19 which is less than half of the response for an increase in paid-sector wage.

2.8 Counterfactual Analysis

This section revisits the structural model and its parameter estimates to perform an experiment and to examine the effectiveness of two sets of policy counterfactuals. The model specification explained in section 2.4 is regarded as the 'Baseline', and its simulation profiles serve as a basis for the comparison of counterfactual regimes. In section 2.8.1, the effect of two counterfactual policies on individuals' career choices and security in retirement is examined; One is changes in payroll tax rates, and the other is introducing self-employment subsidies. After then, section 2.8.2 answers the question of why the LFP rate of the entire sample which includes a subsample of the self-employed is higher than that of the sample which just includes paid-workers and retirees.

2.8.1 Policy Counterfactuals

In order to respond to ageing problems, many governments have exerted efforts to strengthen security in retirement through reforming social security rules and introducing various programs. As the extension of such an effort, I perform two sets of policy counterfactuals. One is changes in payroll tax rates, and the other is self-employment subsidies. These experimental policy analyses suggest the following findings. First, labour supply and sectoral choices sensitively respond to changes caused by payroll tax-rates, and the age-targeted tax policy positively contributes to strengthening financial security in retirement. However, if the tax benefit is just given to very old people, it just has a limited effect. With regard to the self-employment subsidy, although it has a moderate impact on individuals' LFP and career choices, the one-time lump-sum support effectively attracts individuals with the relatively high entrepreneurial ability to the self-employment sector. Furthermore, the earlier age the government provides subsidy, the more effective policy can contribute to the improvement of financial security in retirement.

Changes in payroll tax rates: First, I examine the response of elderly people to the changes in payroll tax rates. The main approaches to encourage older workers to extend their working life have been through social security reform, however, the same goal can be achieved through revision of tax structure levied on labour income near retirement. Also, comparing it with delaying normal retirement age or reduction in SSB amount, tax-cuts would be politically more acceptable. If changes in tax rates for elderly people effectively motivate many of them to stay in the labour force for a longer period, it can contribute to the improvement in financial security in retirement and stability of social security systems.

The policies, which affect the amount of SSB or the pension-eligible age, mainly have an income effect and have a relatively small substitution effect. However, changes in the tax rates have a direct effect on wage rates that a worker actually receives, so it affects both extensive and intensive margins of labour supply.[62] Moreover, when the selection into self-employment is allowed jointly with paid-employment, the degree of impact on each sector would be different. This is because, although the government levies the same tax rate across sectors, the effective social security tax rate can be different; half of the paid worker's payroll tax is shared by employers, however, self-employed need to bear all these amounts on their own. As a result, the effect of payroll tax-cut on business income is twice higher than that of paid-counterparties.

In this subsection, I consider a 25% reduction in the Social Security portion of the Federal Insurance Contribution Act (FICA) and Self-Employment Contribution Act (SECA) tax, and the policy scheme is common knowledge for all individuals.[63] Moreover, the policy effect would depend on the age to which it begins to be applied. Thus, in order to understand the policy effects at different stages of life-cycle, an age-targeted tax-cut applied from the age of 62 and 70 is examined, respectively.[64] Panel (a) and (b) of figure 2.11 show the difference derived by subtracting the simulated LFP rate under the baseline from those under the age-targeted policy regimes, and panel (c) and (d) provide the cumulative policy effect on elderly workers' labour supply choice. Panel (e) and (f) decompose the policy effect (panel

[62] A series of studies demonstrate the close relation between the pension rules and the LFP of older workers (**???**)

[63] The FICA and SECA taxes are levied for paid-workers and self-employed, respectively. The half of tax for paid-workers is shared by the employer, however, self-employed have to bear the entire tax on their own. The tax reduction is not applied to the Medicare tax (Paid-workers Social Security tax rate: 6.20%→4.65%, Self-employed Social Security tax rate: 12.40%→9.30%).

[64] Some countries have introduced age-targeted tax credit similar to the policy counterfactual in this study. For instance, in order to incentivise the elderly to stay in the labour force longer, the payroll tax rate of all workers in Sweden (both paid-workers and self-employed) aged 65 or over was reduced from 26.37% to 10.21% in 2007.

(a) and (b)) across sectors. Table 2.10 decomposes the effect of age-targeted policy by age group, and table 2.11 summarizes the average policy effect on major variables relative to the baseline.

The figure and tables show that tax-cut has both income and substitution effect on the extensive as well as intensive margin of elderly people's labour supply choice. The policy counterfactuals suggest three important points. First, the earlier age the payroll tax reduction is applied, the more the participation decision is sensitive to the changes in the tax rate. The first panel of table 2.10 provides that the average LFP rate increases by 0.25%p between the age group 57-79 if the taxes are reduced from the age of 62.[65] However, if the tax benefit is applied to people aged 70 or over, just 0.11%p more people additionally work on average. Looking closer, the participation response on the extensive margin is concentrated after the age when people are subject to the age-targeted tax credit. Panel (c)-(d) of figure 2.11 show that the cumulative LFP rate before implementing the policy subject to the age from 62 (ages 57-61) and 70 (ages 57-69) increases by just 0.3%p and decreases by 0.8%p relative to the baseline. However, after the implementation of the policy, the participation rate increases by 5.4%p under the policy regime targeted from the age of 62 and 3.4%p under the policy from 70. As a result, the overall cumulative LFP rate (between the age 57-79) increases by 5.7%p and 2.6%p under the policy from age of 62 and 70, respectively.

Second, the age-targeted payroll tax-cut contributes to strengthening elderly workers' financial security in retirement. The first column of table 2.11 shows that each policy increases the average amount of asset holdings by 3.5% and 3.3% relative to the baseline, respectively. With respect to the intensive margin, the policy has a slight negative effect. The third column provides the average total hours of work relative to the baseline. A decrease in payroll taxes directly increases the after-tax hourly wage rate, however, individuals reduce hours of work regardless of the policy counterfactuals. As each of the payroll tax-cut subject to the age of 62 and 70 is executed, individuals' yearly average hours of work decrease by 1 and 3 hours per year relative to the baseline, respectively. However, the negative effect of changes

[65] **?** studies the effect of 25% FICA tax reduction applied to people aged 58 or over and reports that the estimated increase in the average LFP rate between 8 and 12 years after the tax-cut introduction is 4.8% which is 3.1%p higher than the corresponding figure under the tax-cut policy applied to people aged 62 or over in this study. Two factors may bring out the differences. First, the tax reduction in Yavuzoglu is applied to elderly people earlier than in this study. Second, the tax reduction in his study is applied not only to Social Security but also to the Medicare portion of FICA tax. Also, when he derives the amount of tax credit, he includes FICA tax shared by employers. Thus, the payroll tax-cut has a 1.550% (6.20% $\times$ 0.25) wage increase effect in this study, while his study increases the hourly wage rate by 3.825% ($(6.20\% + 1.45\%) \times 0.25 \times 2$). Put somewhat differently, the amount of tax reduction in Yavuzoglu is equivalent to the 61.7% payroll tax-cut in this study.

at the intensive margin is limited, and considering positive changes at the extensive margin as well as a rise in wage rate (pre-tax wage rate (the fourth column)), the positive labour supply effect overrides the negative one. Moreover, the earlier age the policy is eligible, the more the financial stability in retirement will be improved.

Third, the policy causes changes in the sectoral composition of the mode of participation between paid-job and self-employment, and individuals who choose different sectors respond to the changes in payroll tax rates differently. Between the age 57-79, the policy applied from the age of 62 or over cumulatively increases the proportion of both paid-workers and self-employed by 0.4%p and 5.3%p, respectively. Thus, the relative fraction of self-employed among labour force participants increases by 0.5%p (21.71% → 22.17%). In the case of payroll tax-cut which begins to be applied for people aged 70 or over, it has a greater sectoral substitution effect. The policy reduces the number of wage-earners while encouraging more people to become self-employed. Thus, the cumulative fraction of paid-workers decreases by 2.4%p, however, 5.0%p more people work as self-employed.[66]

One of the important caveats in this analysis is that the model cannot take into account the substitution or complementary effects between younger and older workers. The tax-cut reduces the labour cost of hiring elderly workers, so it would raise the relative competitiveness and stimulate the demand of firms to hire more elderly workers. However, a partial equilibrium model just can reflect workers' additional work incentives caused by higher wages, and thus considering the increase in the demand for the elderly, the results presented in this study may underestimate the actual tax policy effects. Moreover, the benefits of elderly people could partially come at the expense of relatively young workers, so in order to evaluate the actual social costs and benefits, the general equilibrium approach is needed. However, the positive effects on security in retirement are still valid and can be greater than the results presented in this study. The other point is financial stability for public spending. Although introducing a tax-cut policy would be politically more acceptable, the fiscal soundness of government can be worsened if the policy fails to encourage a sufficient number of people to stay in the labour force for a longer period. Following the simulation results from the counterfactual payroll tax-cut policy applied from the age of 62, despite the increase of the LFP rate, government revenue from FICA and SECA tax is approximately reduced by 7.6.%[67] Therefore, in order to introduce such a tax policy and to maintain fiscal soundness at the same time, the government needs measures for financing additional resources.

[66] The relative fraction of self-employed among labour force participants increases by 0.51%p (21.71% → 22.22%).

[67] Under the policy regime subject to the age of 70 or over, the amount of tax losses is 2.3%.

Self-employment subsidies: The second policy experiment is examining the effect of introducing a one-time subsidy for individuals who plan to enter self-employment. One of the reasons why governments provide various programs to support people in business start-up activities is that even potentially successful ideas can be of no use if they are not developed into products or services, and thus society loses out not only on the present growth but also on future innovation. The subsidies for self-employed can foster participation by reducing entry costs and risks for a sudden drop in income. Although there is concern that the subsidy just induces individuals with relatively low managerial quality to open a business for the purpose of collecting benefits from the government (**?**), it may be worthwhile if the policy attracts people with high managerial quality who may not choose self-employment without intervention. Actually, some countries, such as Germany, Spain, and Italy, have policies that encourage people to venture into a business.[68] Also, these kinds of policies, once introduced, usually last for an extended period rather than implemented temporarily.

I assume that the government subsidy is offered in the form of a one-time \$30,000 lump-sum support.[69] With regard to the subsidy provision, not only the amount but also the timing at which policies are introduced may cause large changes in the effectiveness of the intervention. Thus, it is additionally considered that the subsidy is given to new self-employment entrants at ages 58, 62, and 66, respectively.

In the perspective of encouraging people to open their own business, the timing of the intervention brings relatively limited changes. The second row of table 2.12 summarizes the long-run effect of the policy intervention on labour supply and career choice. Comparing it with the baseline, if the subsidy is given at age 58, it cumulatively increases the fraction of self-employed by 3.6%p. When the policy is implemented at ages 62-66, 4.2%p and 4.5%p more people cumulatively have self-employment job than in the baseline.[70] However, as the decrease in the number of paid-workers exceeds the increase in self-employed, the average LFP rate slightly drops by 0.23%p and 0.24%p for the case of policy introduction at ages 62-66, respectively. The results show that financial supports introduced near the end of

[68]For instance, in order to guarantee the social security and subsistence of the person setting up the business during the start-up phase, the German government operates "Bridging Allowance (Überbrückungsgeld, §57 Social Code III)" program.

[69]This assumption implies that only those who newly open a business can receive the subsidy. Therefore, self-employed who are currently in business cannot receive such support, however, individuals who enter into self-employment again after shutting down in the past can apply for the benefit. When an individual newly opens his business at a predetermined age, \$30,000 is added to his asset holdings.

[70]The average effect of 58-, 62-, and 66-year-targeted subsidy policy increases the proportion of self-employed by 0.17%p, 0.20%p, and 0.21%p, respectively.

lifetime have a moderate impact, and the later age the government intervenes, the more the policy has an effect on elderly workers' career choice. These would be caused by the fact that $30,000 is not sufficiently attractive for relatively young elderly workers. However, the number of people incentivised to open their own business and the relative value of subsidy rise with health deterioration, decrease in productivity, or both in later life. Also, the relative value of flexibility in deciding working hours and having more control of the working environment rises with age.

In the short-run, relative to the baseline, figure 2.12 shows that the number of self-employed increases by between 0.21%p and 0.33%p in the first year of the intervention. However, the positive effect has disappeared rapidly, so it returns to the rate of the baseline within 1-3 years. Moreover, the intervention causes an immediate drop in the quality of entrepreneurs. For instance, comparing the quality in the first year of the intervention with the quality in the previous year, the mean ability decreases by between 0.5%-1.5%. This is caused by the fact that financial support reduces the entry cost for attempting self-employment and motivates more people to open their own business. However, some of them having relatively poor entrepreneurial ability are just attracted by the subsidy, and thus once they receive the benefit, many of them go out of business quickly (refer to these individuals as 'Cherry Picker'). For example, in the first year of the intervention at age 66 (58), due to the entry of Cherry Pickers, 50th and 75th percentile managerial ability of incumbent self-employed decreases by 3.3% (2.8%) and 24.3% (5.8%), respectively.

Despite the rapid dissipation of positive effects and immediate reduction in entrepreneurial quality, the subsidy may be worth sustaining if its long-run benefits outweigh short-run side effects and the amount of tax expenses required to carry-out. Because expected earnings in the self-employment sector are higher than those in the paid-job on average, flattening entry costs encourage more individuals who have not attempted self-employment. Considering the influential contribution of good entrepreneurs to the growth and innovation, if the intervention can attract more people with the exceptional ability (these type of individuals is referred to 'Actual Entrepreneur' henceforth) to self-employment, the policy could be worth sustaining. Moreover, as improving security in retirement is one of the important objectives, the impact of the intervention on asset holdings should be regarded as a crucial evaluation criterion in the long-run perspective.

In the long-run, the one-time lump-sum support has a positive impact on the economy, and thus it could be worthy of consideration.[71] The intervention attracts

[71] **?** document that a subsidy for entrepreneurship encourages entrepreneurs with low quality more than those of high ability. Thus, in order to justify intervention, the subsidy policy requires a different justification. In their paper, the government provides a subsidy regardless of age. The

more 'Actual Entrepreneurs', so the policy contributes positively to the economy by increasing the overall quality of self-employed. Regardless of intervention timing, the managerial ability evaluated by the dollar amount increases by \$0.36 - \$0.52 per hour on average.[72] Moreover, the policy improves financial security in retirement. The first column of table 2.13 shows that, as the policy encourages more people to have chances of attempting their possibility of success as an entrepreneur, people receive higher wages on average (the fourth column). Also, the earlier stage of life the subsidy is given, the longer period individuals can enjoy higher earnings. For instance, if the intervention is made at age 58, the average level of asset holdings is 1.6% higher than that of the baseline. However, the amount of savings is just 0.9% higher than that of the baseline if the subsidy is given at age 66.

Meanwhile, the amount of additional resources required to implement the policy is another important determinant in assessing the effectiveness of the policy. If the subsidy programme is financed through the per-capita tax at a time, each person has to pay an additional \$379 to \$569 in taxes.[73] However, taking into account the rise in average asset holdings for the age-group 56-79 caused by the intervention, a one-unit of tax increases results in from 3.8 to 4.2 units increase in savings on average. Therefore, the self-employment subsidy policy would be worth implementing; it contributes to the economy by driving innovation and improving the financial stability in retirement, and its long-term benefits outweigh short-term shortcomings.

2.8.2 No Self-Employment Sector

This subsection investigates the extent to which the allowance of transition into self-employment causes people to prolong working lives. Some studies show that self-employment plays a role in extending working lives (**??**). In order to assess the validity of this argument, I compare the simulated life-cycle profiles under the baseline with a profile under the model which does not consider the self-employment sector. This implies that under this new model framework, all people need to work under someone's instruction if they want to work. Thus, the model structure under this counterfactual regime is similar to the standard dynamic life-cycle model

short-term policy effects in this study are similar to them, however, I find that the long-term benefits outweigh the short-term side-effects.

[72]The hourly wage rate, which is evaluated at the mean of self-employment sector-specific experience and managerial ability between the age of 56-79.

[73]For instance, if the intervention is made at age 58, 949 out of 48,968 (the number of survivors) individuals receive the benefits. Therefore, if the government imposes a poll-tax, each individual should pay \$569 in tax. However, if it is made at age 66 (62), 632 (721) out of 44,3675 (46,895) individuals newly become entrepreneurs, and each person needs to pay \$379 (\$433).

suggested by (**??**). Accordingly, all individuals face the paid-sector wage profiles given by equation (2.7), and there is no uncertainty on their ability. This simpler structure model is referred to as 'No-SE' henceforth.

Figure 2.13 compares the simulated profiles under the No-SE with those from the baseline and actual data. Panel (a) provides the LFP profiles from the data and simulations for the age group 57-79. The green square (solid yellow line) shows the participation rate of individuals in the entire sample, and the solid blue-line describes the same statistics from the subsample which just use individuals who have never run their own business during the period under this study. The dotted line is the simulated profiles for the No-SE. Although the alternative specification properly replicates the LFP choice of individuals in the selected subsample (individuals who have never run their own business), the restricted model considerably underpredicts labour supply choice when compared with the entire sample. On average, the LFP rate under the No-SE underpredicts that of the restricted sample by 8.5% (2.8%p), however, it greatly underpredicts the participation rate of individuals in the entire sample by 21.8% (8.3%p).

Panel (b) shows the LFP rate gap under the baseline and No-SE. As the LFP rate of the entire sample is always higher than that of the subsample excluding self-employed, the LFP rate under the baseline is always higher than that of the counterfactual regime. Between the age of 57-79, the participation rate predicted by the No-SE is between 3.5%p and 9.9%p lower than that of the baseline. As a result, relative to the baseline, the restricted model greatly underpredicts the average LFP rate. Moreover, when comparing only the paid workers from each model, the fraction of individuals who choose a paid-job under the baseline (29.7%) is equivalent to the entire LFP rate under the No-SE (29.7%). Moreover, the number of living people choosing the paid-sector in the baseline is consistently higher than in the No-SE from the age of 65. The under-prediction of the LFP rate could be mainly caused by the fact that the restricted model cannot adequately capture the distinguishing characteristics of self-employment which incentivise people to open their own business rather than fully leaving the labour force in the latter part of their career. Due to the flexibility and relatively high expected earnings, self-employment can be an ideal bridge job and can play a role in delaying retirement. However, as the self-employment sector is not considered properly, individuals on the margin of LFP are more likely to choose retirement when marginal negative changes occur.

According to panel (d), the simulated individuals under the No-SE (1,777 hours) work around 66 and 63 hours more per year on average than those under the baseline (1,711 hours) and the actual data (1,714 hours). Once becoming self-employed is disabled, it is not allowed to reduce hours of work by a certain level without experiencing wage penalty. Despite working longer hours, as average hourly wage rates of self-employed are higher than those of full-time workers, individuals under the No-SE receive a lower average wage (panel (e)) and have less assets (panel (c)). The differences of simulated profiles under the baseline and No-SE demonstrate that the career choice between paid- and self-employment sector delay older workers' retirement and allows them to work fewer hours and to enhance financial security in retirement.

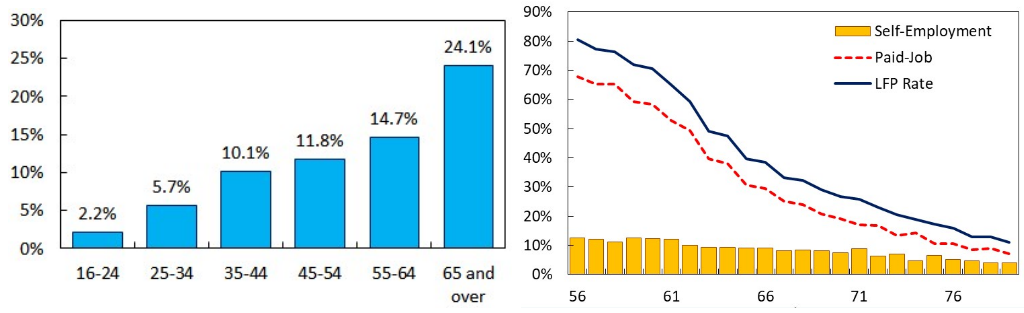
2.9 Conclusion

In this paper, I build a dynamic programming model of elderly people's joint determination of career choice, labour supply, consumption, and social security application. The model allows for the selection into self-employment jointly with paid-employment and retirement. Although the model simplifies many factors, it properly generates the rich patterns of the work and retirement choices observed in the HRS. In particular, the model is doing a good performance in replicating elderly workers' career choice, entry as well as exit decisions of the business they create and suggests reasonable explanation about the cause of these phenomena.

I perform two sets of counterfactual analysis and derives the following findings. In regard to the policy counterfactual, both a 25% reduction in payroll tax rates and the subsidy offered as a form of one-time $30,000 lump-sum support have a relatively small effect on delaying retirement. However, both policies cause large changes in sectoral composition between paid- and self-employment and contribute to strengthening security in retirement. The second counterfactual experiment shows the importance of controlling the self-employment sector. If self-employed are not separated from paid-workers, prediction results would be biased and could not represent the entire elderly people's work and retirement choice adequately. These confirm the importance of controlling selection properly.

Future work which will be added to this study may reflect spouses' labour force decision more explicitly and include a knock-on effect on job creation created by new entrepreneurs. Although this paper studies couples' work and retirement decision, for computational simplicity, the spouses' labour supply choices are treated as an event drawn in a random manner. However, empirical regularity observed in many datasets reveals that an emerging role of women in the labour force requires a better understanding of the coordination of couples' decision-making and its effect on husbands' and wives' behaviour. Also, considering the pivotal role of entrepreneurs in the economy, a better understanding of the chain effect of new and incumbent self-employed persons on job creation and innovation is particularly essential.

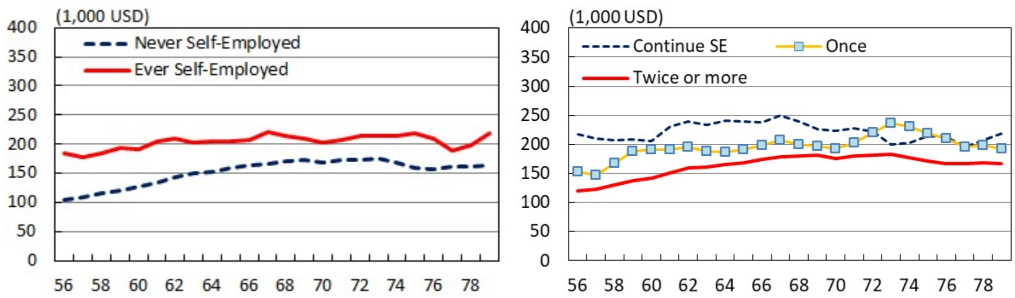
Figure 2.1 Males' labour Force Participation Rate



(a) SE Rate in 2015 (BLS) (b) LFP Rate by Age (HRS)

Notes: Figure (a) shows the percentage of workforce in self-employment sector by age-group. Figure (b) is derived by dividing people in the labour force and each sector into survivors by age

Figure 2.2 Impact of Self-Employment Spells on Net-Asset Holdings for Age 56-79



(a) Having SE Experience or Not (b) # of Newly Opening a Business

Figure 2.3 Duration of Job Spells by Work Status for Age Group 57-75

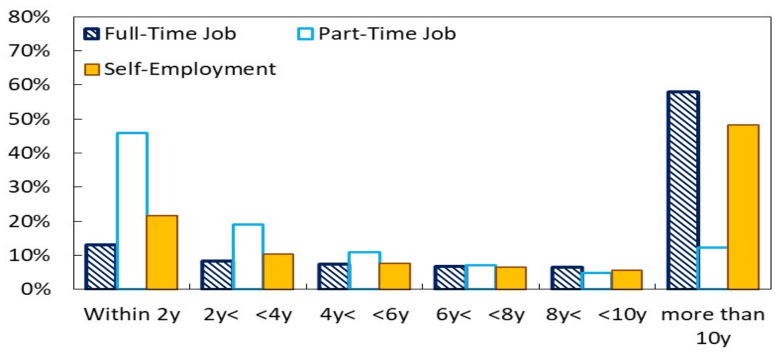
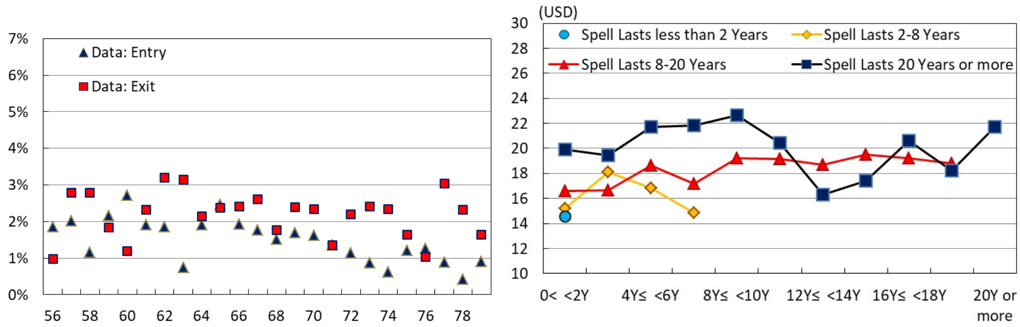
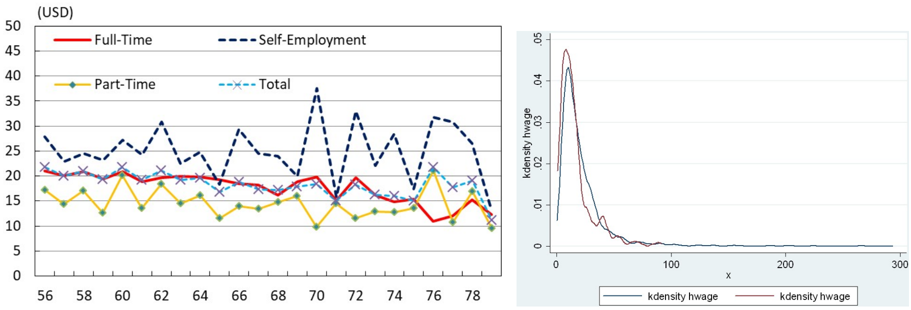


Figure 2.4 Frequency of Entry Into and Exit From SE and Mean of SE Hourly Wage Rate



(a) Entry and Exit (b) By Job-Spells

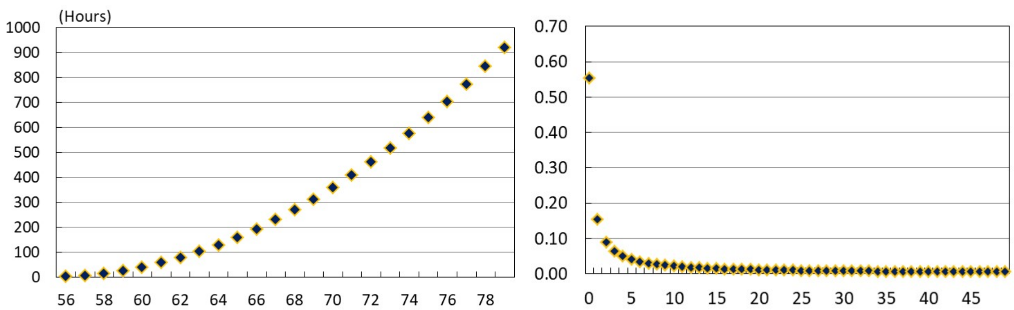
Figure 2.5 Hourly Wage Rate



(a) Mean Hourly Wage Rate By Sector (b) 1st Vs. Having Busi. Exp.

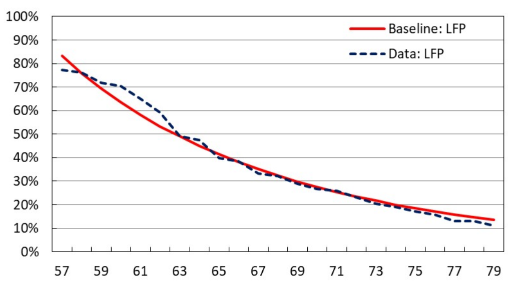
Notes: The wage rates are adjusted for inflation and expressed in 2000 dollars. The blue-line in the right figure describes empirical hourly wage rate distribution of people who tried self-employment just once, and red-line shows that of people who run their own business twice or more during the period under this study

Figure 2.6 Additional LFP Cost and Variance of Posterior Belief about SE Ability

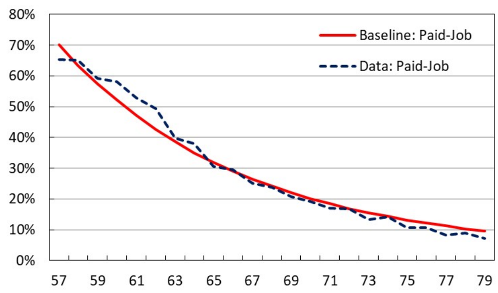


(a) Additional LFP Cost by Age (b) Variance of Posterior Belief

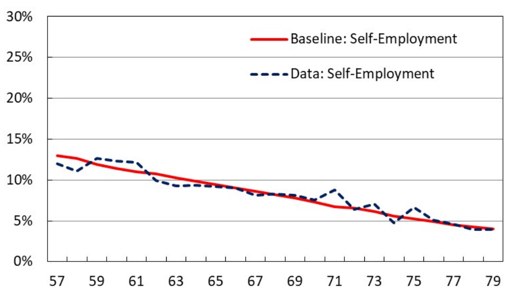
Figure 2.7 Model Fits-Empirical Profiles vs. Simulated Profiles



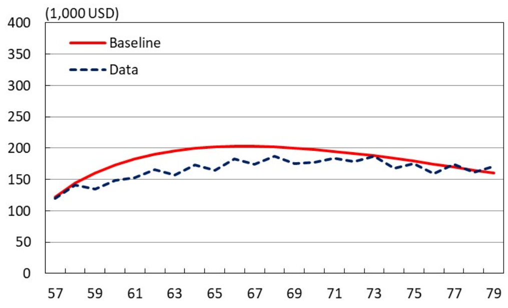
(a) labour Force Participation Rate



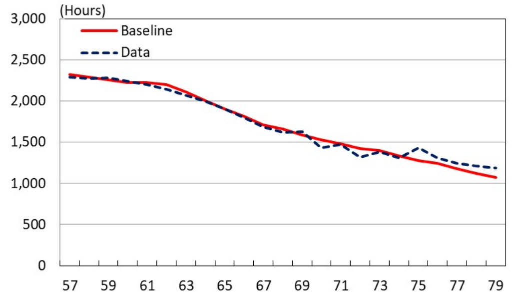
(b) LFP Rate - Paid-Employment



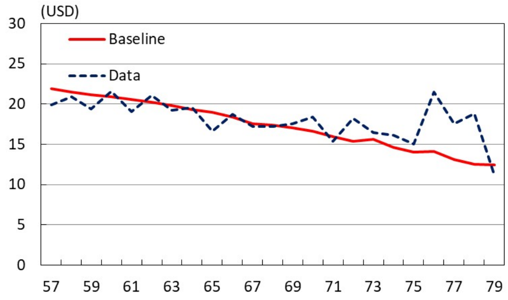
(c) LFP Rate - Self-Employment



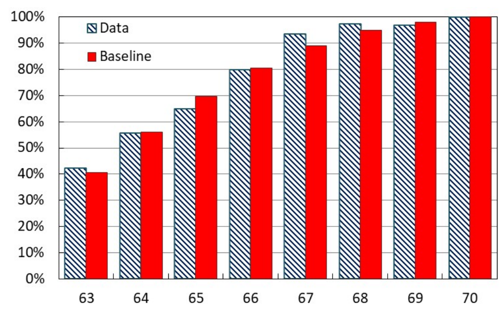
(d) Mean Non-Housing Net Assets



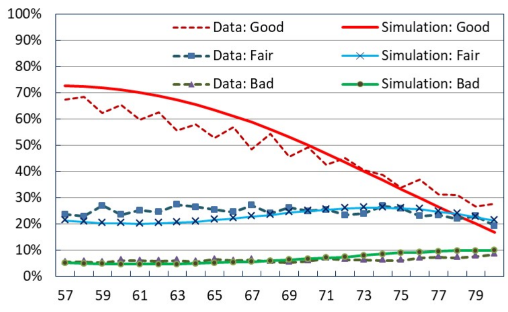
(e) Mean Hours Worked for Participants



(f) Mean Hourly Wages for Participants

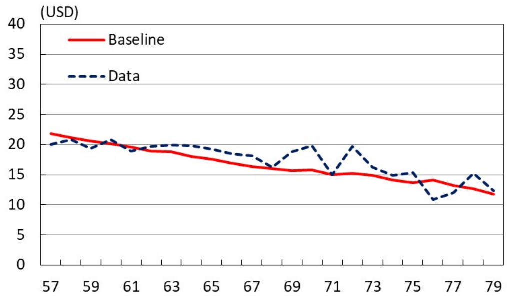


(g) Claiming of Social Security Benefits

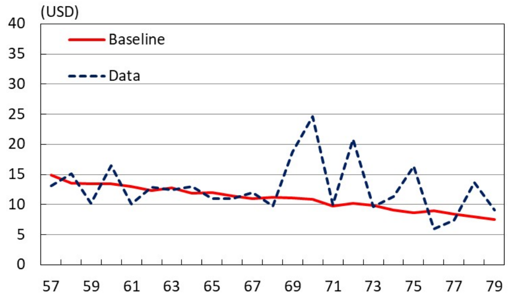


(h) Proportion of Health Status

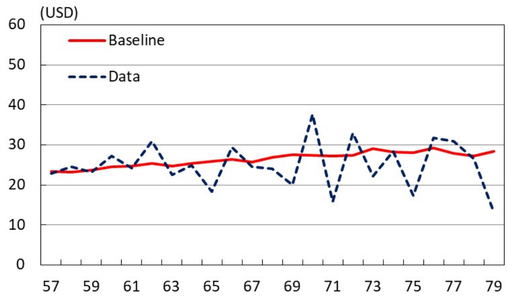
Figure 2.8 Model Fits - Empirical vs. Simulated Profiles: Hourly Real Wage Rates by Sectors



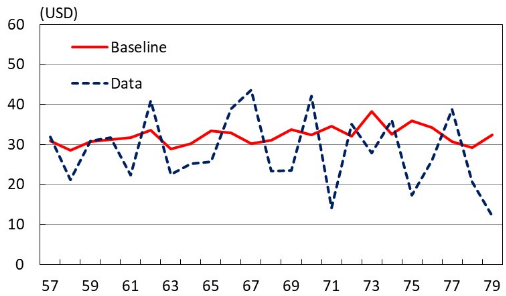
(a) Full-Time: Mean



(b) Full-Time: Standard Deviation

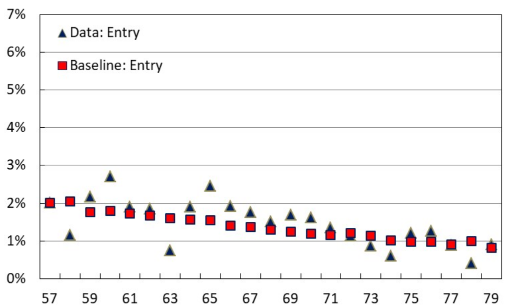


(c) Self-Employment: Mean

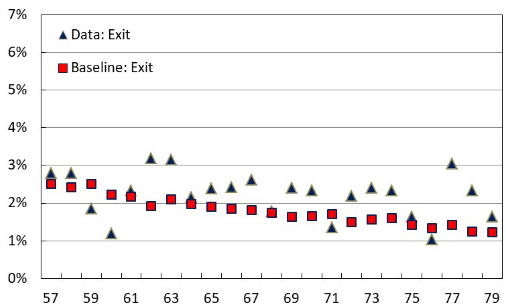


(d) Self-Employment: Standard Dev.

Figure 2.9 Model Fits - Empirical vs. Simulated Profiles: Entry Into and Exit From Self-Employment Sector



(a) Entry Into Self-Employment



(b) Exit From Self-Employment

Figure 2.10 Empirical vs. Simulated Profiles: Duration of Self-Employment Spells

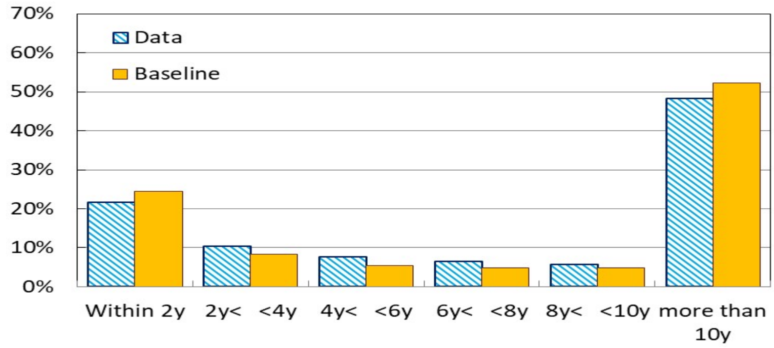
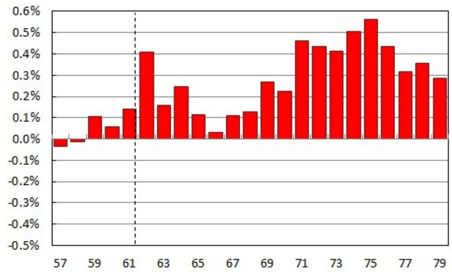
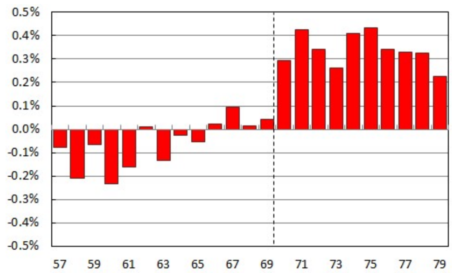


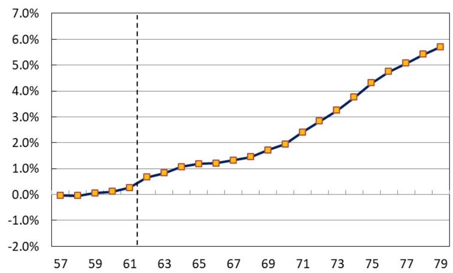
Figure 2.11 Effect of Cutting Payroll Taxes by 25% on LFP[1]



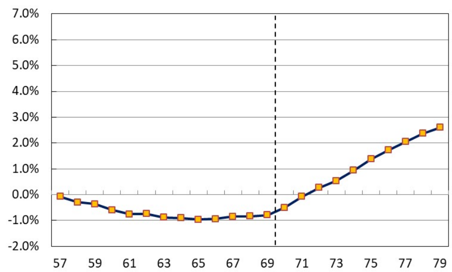
(a) From 62: LFP Rate



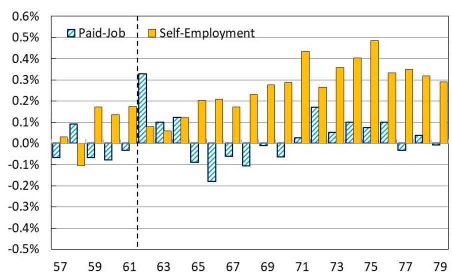
(b) From 70: LFP Rate



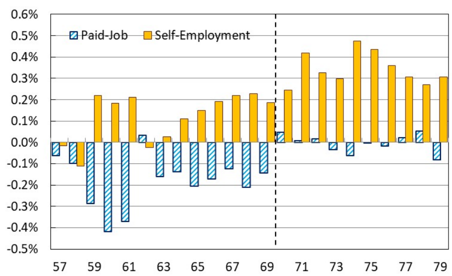
(c) From 62: Cumul. Sum of LFP Rate



(d) From 70: Cumul. Sum of LFP Rate



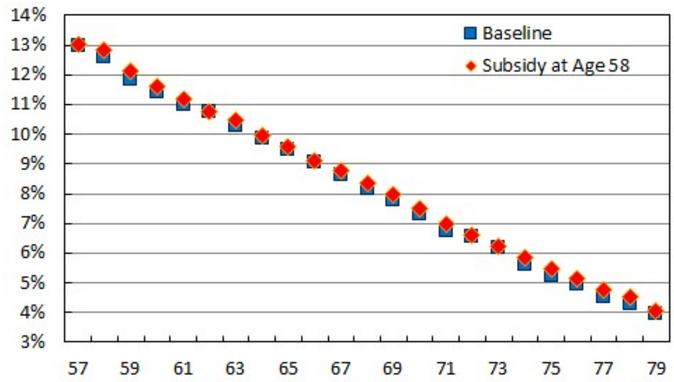
(e) From 62: PJ and SE Rate



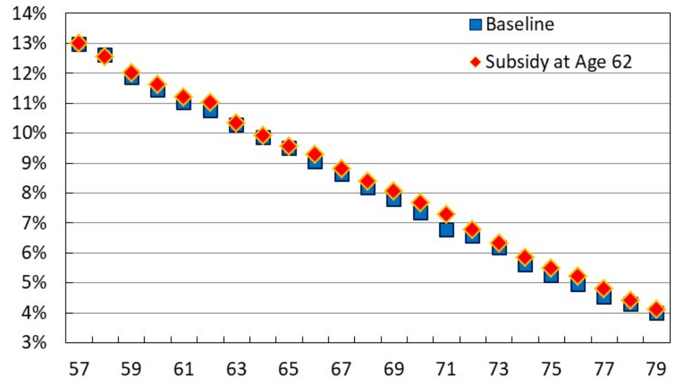
(f) From 70: PJ and SE Rate

Notes: Values in the pictures are expressed as percent point (%p). The numbers in the panel (c) and (d) are summing up the LFP rates under each policy counterfactuals minus the corresponding rates under the baseline. The numbers in panel (a), (b), (e) and (f) are derived by subtracting the LFP rates under the baseline from those under the policy counterfactual

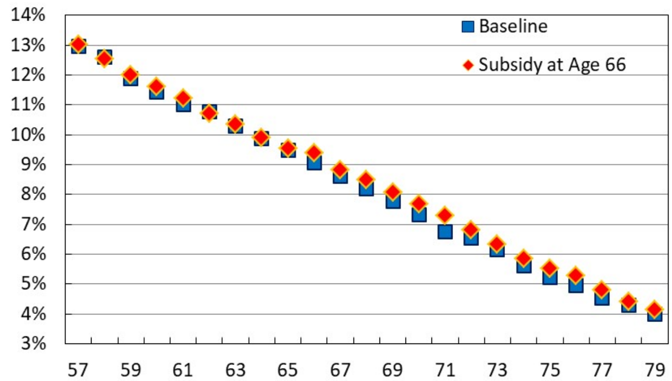
Figure 2.12 Changes in the Self-Employment Rate under Age-Targeted Subsidy



(a) Subsidy at Age 58

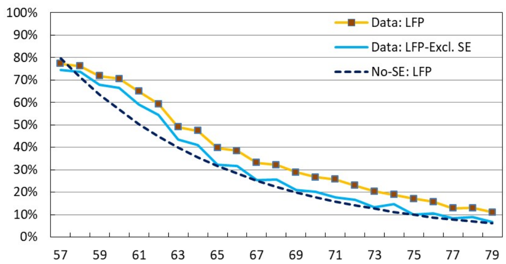


(b) Subsidy at Age 62

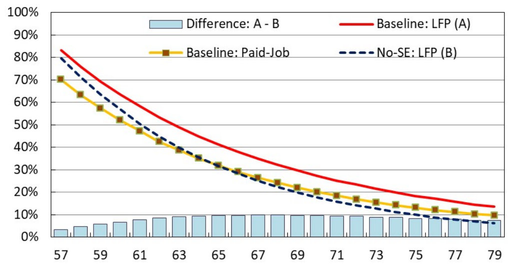


(c) Subsidy at Age 66

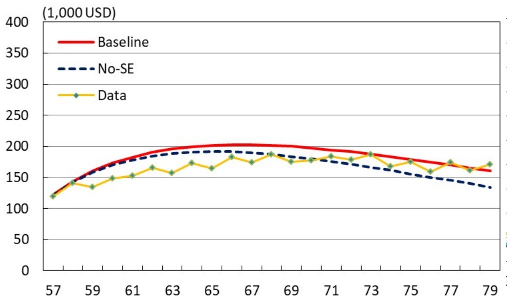
Figure 2.13 Comparison: Baseline Profiles vs. No-SE Profiles



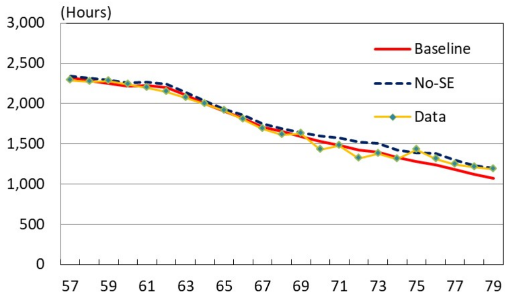
(a) No-SE vs. Actual Data



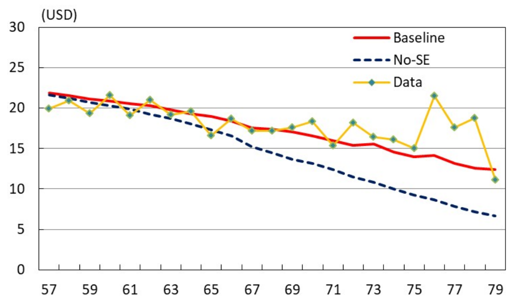
(b) labour Force Participation Rate



(c) Mean Non-Housing Net Assets



(d) Mean Hours Worked for Participants



(e) Mean Hourly Wages for Participants

Table 2.1 Summary Statistics

		FT	PT	SE	RE	Total
Proportion (%)		25.4	9.1	8.9	56.6	100.0
Age (Year)		60.8	67.1	64.4	69.1	66.4
		(4.3)	(6.0)	(6.3)	(6.2)	(6.8)
Educational	High-School or Below	49.6	51.7	42.0	63.2	56.6
Attainment	College	23.1	21.9	22.3	18.8	20.5
(Proportion (%))	B.A. or Higher	27.3	26.4	35.6	18.1	22.8
Hourly Real	Average	19.7	14.5	24.9		19.5
Wage ($)		(13.2)	(19.2)	(30.1)		(18.6)
	1st Quartile	11.7	6.9	8.5		9.5
	Median	17.0	9.0	15.8		15.1
	3rd Quartile	24.4	14.0	28.2		23.2
Hours of Work	Average	2,344	1,020	1,994		2,031
(Hours)		(477)	(409)	(967)		(776)
	1st Quartile	2,080	720	1,300		1,600
	Median	2,080	1,040	2,080		2,080
	3rd Quartile	2,600	1,300	2,600		2,496

Notes: The numbers in the table show average profiles for the age group 56-79. Monetary values are expressed by year-2000 U.S. dollars. Standard deviation is presented in parenthesis

Table 2.2 Career Transition Probabilities by Age Group

		Status in t+2		
	Status in t	Paid-Job	Self-Emp.	Retirement
Age: 56-66	Paid-Job	77.9%	2.1%	20.0%
	Self-Employment	11.1%	75.7%	13.2%
Age: 67-79	Paid-Job	26.1%	17.4%	56.5%
	Self-Employment	35.0%	14.7%	50.2%

Table 2.3 Reasons for Retirement and Career Transition Across Sectors[1]

From Status at t-2 to Status at t	PJ to RE	FT to RE	PT to RE	SE to RE
Involuntary Retirement	37.1%	33.8%	44.0%	54.7%
- Business Closure or Lay-off	17.3%	14.6%	23.0%	27.4%
- Retired, Negative Change in Working Cond.	8.8%	11.5%	3.2%	1.1%
- Poor Health	11.0%	7.8%	17.7%	26.3%
Voluntary Retirement	61.7%	65.0%	54.8%	41.1%
- Leisure	46.5%	53.0%	33.1%	0.0%
- Voluntary Quits	10.7%	7.2%	18.1%	38.9%
- Financial Incentives	3.0%	4.5%	0.0%	0.0%
- Changes in External Circumstance	1.4%	0.4%	3.6%	2.1%
Others	1.2%	1.2%	1.2%	4.2%

From Status at t-2 to Status at t	PJ to SE	FT to SE	FT to PT	SE to PJ
Involuntary Career Transition	36.7%	34.8%	44.7%	29.7%
- Business Closure or Lay-off	26.5%	26.1%	36.8%	27.0%
- Retired, Negative Change in Working Cond.	6.1%	6.5%	2.6%	0.0%
- Poor Health	4.1%	2.2%	5.3%	2.7%
Voluntary Career Transition	63.3%	65.2%	47.4%	70.3%
- Leisure	16.3%	17.4%	23.7%	0.0%
- Voluntary Quits	42.9%	43.5%	13.2%	64.9%
- Financial Incentives	4.1%	4.3%	2.6%	5.4%
- Changes in External Circumstance	0.0%	0.0%	7.9%	0.0%
Others	0.0%	0.0%	7.9%	0.0%

Notes: The numbers in the table combine answers to the two questions: a) "Why did you leave your previous employer [stop at working at your previous business]" and b) "Did your employment [business] situation change in some way that encouraged you to leave". "Retired, negative change in working condition" includes workers who choose retirement as the reason they left their previous sector and, with regard to the change in their working conditions, report that a) departure was encouraged by supervisor or co-workers, b) their wages or hours had or would have been cut if they had stayed, c) they would have been laid off, d) they had new job duties, e) they had to move to a new job location, f) their health insurance or work schedule had changed by their employer or g) other working conditions had negatively changed. "Leisure" includes workers a) who report that they left their employer because of enjoying travels, spending more time at home or distance to work or b) who answer that they have retired without changes in working conditions. "Voluntary Quits" includes workers who left their employer because of a) starting own business, b) finding a better job, c) burned-out, d) the sale of their business or hand-over responsibilities to other family, or e) wanting to changes. "Financial Incentives" includes workers who a) receive an early retirement incentive, b) think that stop working is financially advantageous or c) become eligible for pension, social security or special early retirement offer or receive better job offers. "Changes in External Circumstance" includes divorce, spouse's transfer or family moving
Source: HRS (2002-2014 survey)

Table 2.4 Estimates of Medical Expenses

Dependent Variable: $ln(m_{it})$		
age_{it}	0.148	(0.165)
age_{it}^2	-0.002	(0.002)
age_{it}^3	-0.00001	(0.00001)
$college_i$	0.149**	(0.016)
$ln(a_{it})$	0.052***	(0.005)
$Fair - Health_{it}$	0.270***	(0.018)
$Bad - Health_{it}$	0.488***	(0.033)
$Eligibility\ for\ Medicare_{it}$	-0.059	(0.071)
$constant$	2.759	(3.827)
σ_u^2	1.429	

Note: Robust standard errors are presented in parenthesis: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 2.5 The Estimates of Preference Parameters

Params.	Definition	Coef.	S.E.
α_{Good}	Consumption Weight: Good health	0.535	(0.012)
α_{Fair}	Consumption Weight: Fair health	0.560	(0.080)
α_{Bad}	Consumption Weight: Bad health	0.575	(0.084)
σ	Relative Risk Aversion	6.691	(0.641)
c_{min}	A Minimum Level of Resources ($1,000)	8.996	(0.113)
$\overline{L}$	Time Endowment (hours)	5,805	(7.771)
θ_P	Fixed Cost of Work (hours)	742.0	(9.713)
θ_{PA}	Coeff. of Fixed Cost of Participation by Age (hours)	1.617	(0.026)
θ_{SE}	Fixed Cost of Becoming Self-Employed (hours)	356.3	(7.995)
θ_{Fair}	Fixed Cost of Work -Fair Health (hours)	552.1	(7.997)
θ_{Bad}	Fixed Cost of Work -Bad Health (hours)	1029.0	(14.361)
θ_{BE}	Bequest Shifter	0.024	(0.000)
K	Bequest Curvature ($1,000)	5.327	(0.362)
θ_{RV}	Fixed Utility Cost of Returning to Work	-0.0093	(0.0002)
θ_0^B	1st Coeff. of Mean SSB Application Costs	-0.074	(0.0020)
θ_1^B	2nd Coeff. of Mean SSB Application Costs	0.002	(0.0000)
θ_2^B	3rd Coeff. of Mean SSB Application Costs	0.002	(0.00000)
μ_η	Mean of Non-Pecuniary Benefits	-0.0001	(0.000003)
σ_η	Std. of Non-Pecuniary Benefits	0.0095	(0.000002)

Table 2.6 The Estimates of Earnings Process Parameters

Paid-Job				Self-Employment			
Params.	Description	Coeff.	S.E.	Params.	Description	Coeff.	S.E.
β_0^{PJ}	Age	0.0774	(0.0009)	β_0^{SE}	Age	0.0897	(0.0013)
β_1^{PJ}	Age Squared	- 0.0009	(0.0000)	β_1^{SE}	Age Squared	-0.0006	(0.0000)
β_2^{PJ}	Sector Experience	0.0068	(0.0001)	β_2^{SE}	Sector Experience	0.0037	(0.0001)
β_3^{PJ}	Fair Health	- 0.1957	(0.0027)	β_3^{SE}	Fair Health	-0.0995	(0.0015)
β_4^{PJ}	Bad Health	- 0.3158	(0.0042)	β_4^{SE}	Bad Health	-0.1521	(0.0026)
μ_f	Constant	1.3007	(0.0026)	μ_φ	Constant	-0.4950	(0.0081)
ρ_{AR}	Autoregressive	0.3904	(0.0050)	ρ	Corr.: PJ & SE	0.5239	(0.0069)
σ_f	Std. of FE	0.5716	(0.0074)	σ_φ	Std. of SE	0.8725	(0.0129)
σ_ξ	Std. of Innovation	0.2007	(0.0026)	σ_ψ	Std. of Innovation	0.4588	(0.0073)
ς	PT-Job Penalty	0.3415	(0.0044)				

Table 2.7 Transition Probabilities Between Paid-Job and Self-Employment

$56 \leq \text{Age} \leq 79$		Status in t+2		
	Status in t	Full-Time	Part-Time	Self-Emp.
Data	Full-Time	87.8%	9.5%	2.7%
	Part-Time	14.4%	82.0%	3.5%
	Self-Employment	5.3%	5.8%	88.8%
Baseline	Full-Time	89.0%	7.4%	3.6%
	Part-Time	22.8%	67.8%	9.3%
	Self-Employment	13.4%	6.2%	80.4%

Note: Each column presents the simulated or the actual probability of choosing each sector at period t and choosing the same or different sector at period t+2 conditional on the labour force participants at period t

Table 2.8 Frisch Elasticity of Labour Supply

	Intensive Elasticity (A)			Extensive Elasticity (B)			Agg. Elasticity (A+B)		
	All	PJ	SE	All	PJ	SE	All	PJ	SE
At Age 60	1.055	1.039	1.152	0.000	0.000	0.000	1.055	1.038	1.152
At Age 66	1.416	1.395	1.492	0.015	0.009	0.006	1.430	1.404	1.497
At Age 70	1.770	1.708	2.009	0.035	0.011	0.024	1.806	1.719	2.033

Note: The extensive margin shows the percentage point changes in LFP in response to 1% increase in hourly wage

Table 2.9 20% Increase in Hourly Wage Rate and Labour Supply Responses

	All Sectors			Paid-Job			Self-Employment		
	All	PJ	SE	All	PJ	SE	All	PJ	SE
Intensive Elasticity (A)	0.14	0.11	0.25	0.11	0.14	0.00	0.03	-0.02	0.19
Extensive Elasticity (B)	0.25	0.06	0.19	0.24	0.42	-0.18	0.16	-0.00	0.17
Aggregate Elasticity (A+B)	0.39	0.17	0.44	0.35	0.56	-0.19	0.19	-0.02	0.36

Notes: The permanent increase in hourly wage occurs from the age of 60. The average of labour supply profiles for the age group 57-79. The extensive elasticity shows the percentage points changes in LFP in response to 1% increase in hourly wage during the period under study

Table 2.10 Payroll Tax Change and Career Choice

	Paid-Job	Self-Employment	LFP
	Total ($57 \leq$ Age ≤ 79)		
Baseline	29.68%	8.23%	37.92%
From the age at 62	29.70%	8.46%	38.17%
From the age at 70	29.58%	8.45%	38.03%
	$57 \leq$ Age ≤ 61		
Baseline	58.09%	11.98%	70.07%
From the age at 62	58.06%	12.06%	70.12%
From the age at 70	57.85%	12.08%	69.92%
	$62 \leq$ Age ≤ 79		
Baseline	21.79%	7.19%	28.98%
From the age at 62	21.82%	7.46%	29.39%
From the age at 70	21.73%	7.44%	29.17%
	$57 \leq$ Age ≤ 69		
Baseline	41.59%	10.30%	51.89%
From the age at 62	41.59%	10.44%	52.03%
From the age at 70	41.41%	10.42%	51.83%
	$70 \leq$ Age ≤ 79		
Baseline	14.21%	5.54%	19.75%
From the age at 62	14.25%	5.89%	20.15%
From the age at 70	14.20%	5.89%	20.09%

Notes: The average of career choice profiles for the age group 57-79. The share of paid-workers and self-employed in entire population ($\frac{Each-Career}{Total\ number\ of\ individuals\ in\ the\ sample}$)

Table 2.11 Payroll Tax Change and Major Lifecycle Profiles

Counterfactual Regime	a_{it+1}	Payroll-Tax	h_{it}	w_{it}	SSB	φ_i
From the Age of 62	103.53	92.38	99.96	102.11	-0.05%p	107.65
From the Age of 70	103.26	97.66	99.82	101.48	-0.07%p	106.93

Notes: The average of simulated profiles for the age group 57-79 under each counterfactual regimes. The simulated average figures under the baseline set at 100. The figures in the column 3 shows government's payroll tax revenue which is used to finance OSADI and Medicare Hospital Insurance programmes (FICA and SECA). The figures in the column 5 are derived as follows: (1) For each counterfactual regimes and the baseline, deriving the average share of people who drawn Social Security Retired Worker Benefit at the ages 63-69 and (2) subtracting the average share under the baseline from that of each counterfactual regime

Table 2.12 Self-Employment Subsidy and Career Choice

Counterfactual Regime	Paid-Job	Self-Employment	LFP Rate
Baseline	29.69%	8.22%	37.92%
SE Subsidy at Age 58	29.54%	8.39%	37.93%
SE Subsidy at Age 62	29.26%	8.42%	37.68%
SE Subsidy at Age 66	29.25%	8.43%	37.68%

Notes: The average of career choice profiles for the age group 57-79. The share of paid-workers and self-employed in entire population ($\frac{Career}{Total\ number\ of\ individuals\ in\ the\ sample}$)

Table 2.13 The Effect of Providing Self-Employment Subsidies

Counterfactual Regime	a_{it+1}	Payroll-Tax	h_{it}	w_{it}	SSB	φ_i
Subsidy at Age 58	101.59	100.08	99.86	101.59	-0.09%p	104.09
Subsidy at Age 62	100.89	99.59	99.87	103.07	-0.15%p	105.89
Subsidy at Age 66	100.87	99.54	99.86	103.10	-0.15%p	105.40

Notes: The average of simulated profiles for the age group 57-79 under each counterfactual regimes. The simulated average figures under the baseline set at 100. The figures in the column 3 shows government's payroll tax revenue which is used to finance OSADI and Medicare Hospital Insurance programmes (FICA and SECA). The figures in the column 5 are derived as follows: (1) For each counterfactual regimes and the baseline, deriving the average share of people who drawn Social Security Retired Worker Benefit at the ages 63-69 and (2) subtracting the average share under the baseline from that of each counterfactual regime

Chapter 3

Wealth Shocks, Income Shocks, and Consumption Insurance

3.1 Introduction

A voluminous literature estimates how changes in wealth affect household consumption.[1] The literature sheds lights on the magnitude of the wealth effect as well as the channels through which changes in wealth affect household consumption. For instance, an increase in wealth may raise consumption by expanding the budget (spendable cash in hand) or through relaxing borrowing constraints by raising households' creditworthiness. These channels may work differently.

An extensive literature exploits a representative agent model and estimates the wealth effects using aggregate data (???).[2] However, the estimated wealth effect using aggregate data may not capture the potential individual or household heterogeneity in an appropriate manner, so the disaggregated micro-data would be desirable to yield a consistent estimate of the wealth effect (?).[3] For instance, ? estimate the effect of shocks in unemployment, housing, and financial wealth on consumption using two waves of internet survey on U.S. households. ? and ? estimate the response of household consumption to house prices using Danish and UK micro-data, respectively. ? decompose the wealth effect into endogenous and

[1] Unless specified otherwise, by wealth we mean nonhuman wealth of households, such as financial or housing wealth.

[2] A related literature uses time-variation in aggregate data across countries to estimate the effect of wealth shock on consumption (?????). For instance, ? find consumption is more responsive to housing gains based on estimate of aggregate data in 14 countries and U.S. states.

[3] Estimates of housing wealth effect on average consumption may differ in microdata and in aggregate data. However, ? illustrate that if individual heterogeneity does not vary over time and is not correlated with the variables of interest, the use of aggregated data does not cause aggregation bias.

exogenous components and focus on the impact of anticipated and unanticipated changes in the exogenous component of wealth on consumption using Italian micro-data.[4]

Parallel to this literature, a growing literature has focused on how idiosyncratic permanent and transitory income shocks are transmitted to innovations in household consumption (**?????**). The parameters that quantify the passthrough of permanent and transitory income shocks to consumption are typically referred to as insurance parameters (a perfect passthrough means zero insurance). One insight from the literature is to understand the evolution of consumption inequality relative to that of income inequality, where insurability of income shocks play a key role. However, the literature still has not investigated the relationship between household wealth and consumption inequality. Optimal consumption response to shocks in human wealth (*i.e.* income shocks) depends on the households' holding of financial and housing wealth. If a household chooses holdings of different types of assets in a joint decision, its financial, housing, and human wealth should be correlated.[5]

This paper bridges the gap between these two literature. We extend the analysis of the wealth effect from the first moment of consumption (average) to the second moments (inequality and covariance with the income shocks). Given that housing wealth was a dominant component of a household's balance sheet in the data we use, we focus on the wealth held in the form of a house and the housing price changes. Our empirical analysis of the wealth effect on consumption growth and inequality takes two steps. First, we obtain consistent estimates of the wealth effect on the mean of consumption growth, exploiting the differential effect of the housing price change on households with a different fraction of remaining lifetime wealth held in the form of a house. Second, we decompose the residual consumption growth (deviation from the mean) from the first step estimation to identify the component of income shocks and consumption insurance parameters. We follow **?** and connect consumption insurance with income shocks. However, we introduce more heterogeneity and allow for differential consumption response varying on time, household wealth, and exogenous housing market-driven wealth shocks. Thus, our

[4] One focus of studies on both aggregate and micro data is the marginal propensity to consume of gains in different assets. **?** find PSID households are more responsive to gains in stocks than housing. Another focus of the wealth effect literature is the heterogeneity of marginal propensity to consume for different household groups, e.g., **?** find UK old households are more responsive to wealth shocks. A third focus is on how consumption is related to predicted future wealth (**??**).

[5] For instance, homeownership may indicate creditworthiness that makes homeowners less responsive to income shocks, which means wealth is positively correlated with consumption insurance through the credit channel. On the other hand, homeowners may have more committed expenditures and have to make more adjustments to non-committed expenditures (**?**).

approach allows us to quantify the relative importance of household wealth in explaining changes in consumption inequality.

There are three challenges to identify the effect of the changes in wealth on consumption. First, changes in wealth reflect not only the price changes driven by the asset markets but also the household's endogenous portfolio choices. Given that the households make portfolio choices and consumption jointly, the regression of consumption growth on changes in assets may not yield causal effects (**?**). Second, a single or multiple common factors can drive both consumption and asset prices in the same direction. For instance, the asset prices may be correlated with the expectation of future productivity growth, and households would adjust their consumption taking into account their expectation of future growth (**?**). If it is the case, then the observed synchronization between the house price change and consumption change just indicates a spurious association. Finally, errors in measuring wealth impose additional difficulties to consistently estimate the wealth effect.

To tackle these challenges, we construct a housing wealth shock by exploiting the exogenous variation of housing price changes and the lagged fraction of remaining lifetime wealth held in housing asset.[6] Essentially, we are comparing household consumption changes with respect to housing price changes for households who have a large housing wealth (as a fraction of remaining lifetime wealth) relative to those who have a small-housing wealth. Our identification strategy allows for controlling endogeneity and reducing attenuation bias caused by measurement errors in wealth observations.

We estimate our empirical model using household-level panel data of consumption, income, and wealth for Korean households. Our data set is the Family Income and Expenditure Survey in urban areas of Korea from 1994 to 2002. The survey covers monthly observations of around 5,000 households and is collected by diary. Thus, it provides detailed high-frequency information and tracks changes in wealth, income, and consumption.[7] Moreover, as the sample period covered the Asian financial crisis, it allows us to examine the relation between the changes in

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[6]We define lifetime wealth as the sum of the current amount of asset holdings and the present value of expected future income. The detail of our way to measure lifetime wealth is explained in Appendix C.1.

[7]The Korean household data have two important advantages over other household survey data such as the CEX or PSID. First, contrary to other data sets which collect information on a yearly basis, our data set has long monthly panels (each household are covered over 12 to 60 months). Thus, it is less likely to suffer from aggregation bias and provides detailed high-frequency information. The other is that our data is a representative real panel of households with comprehensive information on consumption, income, and wealth. Households directly fill in the family account book with daily income and expenditure. Also, the data contain rich detail of the information of account-level data on a diverse kind of asset holdings and their transactions. Thus,

household wealth and consumption growth and households' consumption response to income-driven shocks.

The main empirical findings are as follows. First, our constructed wealth shock has a high predictive power to explain the changes in the amount of household wealth and a large positive effect on consumption. A 10% changes in the constructed wealth shock is associated with the changes in household wealth by 9.3% and causes 18.6% increase in consumption. The estimated coefficient of the wealth effect implies that a 1% increase in the nationwide house price index leads to a rise in monthly consumption by 0.45% on average. The estimated wealth effect is neither exceptionally high nor low and comparable with other studies (**??**) and qualitatively robust to various changes in the model specifications.

Second, the estimated consumption insurance with respect to the permanent and transitory income fluctuation is smaller than one (partial insurance), and the effect of transitory shocks on consumption is smoothed more than that of the permanent one. The results are equivalent to previous studies.[8] The estimated average consumption insurance against permanent and transitory income shocks is 0.633 and 0.136, respectively. These imply that 86.4% of transitory income shock can be insurable, however, 63.3% of permanent income shock is transmitted to the consumption growth.

Finally, there is a large degree of differences in the ability to smooth consumption, and these are caused by the heterogeneity of the household wealth held in the form of the house. A 1% increase in house price inflation is associated with the improvement in the ability to insure consumption against permanent income shock by 0.013%. However, the constructed wealth shock just has a limited effect on the transmission of the transitory income shock. Also, the decrease in consumption inequality after the crisis is partly captured by the improvement in the ability to insure consumption against permanent income shock. 21% more permanent shock to consumption becomes insurable after the crisis. This partly reflects the institutional changes that occur after the crisis; the mortgage markets become more competitive, and people are more accessible to the housing financial market.

The rest of the paper proceeds as follows. Section 2 presents institutional background on housing market in Korea. Section 3 explains our empirical models. First, we estimate the casual effect of the constructed wealth shock on consumption growth. Then, we decompose the residual from the first step estimation to identify

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it is suitable for examining relation between the changes in household wealth and consumption growth and households' consumption response to income driven shocks.

[8] **???** show that the estimated ability to insure consumptions against permanent and transitory income shocks supports the argument of partial insurance.

the degree of consumption insurance with respect to the income shocks. Section 4 describes the data and key variables. Section 5 explains about estimation results. Section 6 concludes.

3.2 Institutional Background

As housing assets take a significant proportion of total household wealth, changes in house price can have a substantial impact on households' choice of consumption. In Korea, around 60% of household observations in our sample were house owners at some period between 1994 and 2002. Comparing it with other western countries which housing assets account for half to two-thirds of wealth, home-ownership is particularly important for Korean households because around 90% of the total wealth was held in the form of house or housing deposit, and holding other forms of assets was much uncommon. Thus, housing wealth is a particularly important component of the household portfolio in Korea, and there would be ample room for the changes in housing wealth to play an important role through the impact on the financial situation of households before and after the crisis.

Our sample covers the period of the Asian Financial Crisis which appears to have had a huge impact on Korea economy and housing market. National level house price in Korea remained stable between 1994 and 1997, and the national house price index just increased by 3.1% during the given four-year period (from 60.4 to 62.3). However, as the economic crisis hit hard Korea in late 1997, the Korean won devalued sharply, the stock price declined, and the unemployment rate jumped. In late 1998, there were indications that the crisis was over and the Korean economy staged a dramatic recovery through 1999. The Korea housing market also underwent a drastic change during and after the crisis. The housing price began to fall sharply after the onset of the crisis, and this decreasing trend continued until early 1999. The index recorded its trough in January 1999 and fell by 11.8% compared to its peak in October 1997. After undergoing a sharp drop, house price rebounded since early 1999 and had recorded a rapid increase since late 2000. In early 2002, the housing price index exceeded its previous highest level, and it increased by 27.9% between December 2000 and December 2002.

Along with the economic recovery, a series of changes in housing policy led to a rapid rebound of the housing market. Before the crisis, the supply of capital to the households was limited, and thus the lending between non-institutional private citizens prevailed (**?**). However, as the Korea government asked the International Monetary Fund (IMF) for stand-by loans, it agreed to implement drastic measures to reform its economy and financial (including housing) policies. One of the noticeable changes is the housing finance market. The government privatised the Korea Housing Bank (KHB), which had accounted for over 70% of new housing loans in 1995 and enacted new laws including the Asset-Backed Securitization Act in 1998 and laws for creating secondary mortgage cooperation in 1999 (Mortgage-Backed Securitization Company Act).[9] As a result, the mortgage markets become more competitive, more diverse housing loan products have introduced, and housing loan increased rapidly as a series of changes has enabled more people to access financial markets (**?**).[10]

3.3 Empirical Strategy

3.3.1 An Empirical Model of Consumption Wealth and Income

In the literature on the causal effect of wealth on household consumption, a common approach is regressing consumption growth on changes in wealth, with household income as a control variable. For instance, **?** regress the growth rate of total household consumption expenditure on a vector of variables that include anticipated and unanticipated growth in income and housing price, along with county-year dummies and measurement errors. The focus is on the housing price on the average household consumption.

In the consumption inequality literature, a common practice is to follow a two-step procedure. The first step is to remove predictable components of consumption. The second step is to estimate a model of components of the residual consumption from the first step. For instance, in their first-step, **?** (call it as *BPP* henceforth) regress growth of household consumption on household demographic variables and year dummies. The first-step removes the effect of the variables that affect the average household consumption. The main object of the study is the variance of residuals of consumption growth. In their second step, BPP decompose the residuals of consumption growth into responses to permanent and transitory income shocks. The two-steps of BPP can be reconciled with a lifecycle model of consumption optimization. The first-step removes predictable preference shifters, and the second step links innovations of consumption attributable to permanent and transitory shocks in income. In the lifecycle model innovations in consumption depend on

[9] After introducing ABS laws, the securitization of mortgages has been permitted first in Korea.

[10] The total in loans outstanding of commercial and small banks to the household sector in Korea was 29% in 1997 which recorded 47% in 2002.

wealth shocks as well as income shocks. In the BPP second-step model wealth shocks is implicitly included in an *i.i.d.* error term.

We follow the two-step approach of the consumption inequality literature. Our first-step model divides consumption growth into three parts: predicted components, wealth shocks and income shocks. The second-step model estimates innovations of consumption attributable to income shocks. Our approach differs from the common practice of the consumption inequality literature in that we focus on how proxies of wealth correlate with the size of household income shocks and on how they affect consumption responses to income shocks; and that we explicitly account for the effect of wealth shocks in the first-step on consumption inequality.

$$\Delta C_{it} = \alpha + \underbrace{\gamma \Delta a_{it}}_{\text{Wealth Changes}} + \delta \boldsymbol{X_{it}} + \tau_t + \underbrace{\phi_{it}\zeta_{it} + \psi_{it}\varepsilon_{it} + \xi_{it}}_{\text{Income Shocks: } \Delta c_{it}} \tag{3.1}$$

where C_{it} denotes log monthly consumption of household i at time t, and a_{it} is net-wealth which will be referred to “wealth" henceforth. γ captures the effect of wealth change Δa_{it} on consumption growth. $\boldsymbol{X_{it}}$ is a set of observable demographic covariates, which includes age, age-squared, occupation, size of household, number of children, and educational attainment. τ_t denotes a full-set of year-month dummies capturing all the unobserved factors that change aggregate consumption growth. Following BPP, the residual of consumption growth Δc_{it} is decomposed into the income shocks and the degree of transmission of income shocks to consumption. ζ_{it} and ε_{it} are permanent and transitory income shocks, respectively. ϕ_{it} and ψ_{it} are parameters measuring the transmission of permanent and transitory income shocks to consumption growth, which are allowed to potentially vary over both i and t. This implies that the magnitude of transmission of ζ_{it} and ε_{it} to consumption growth can differ. In general, the closer the parameters to zero, the higher is the degree of self-insurance against income risks.[11] In models with self-insurance through precautionary savings, ψ_{it} is typically smaller than ϕ_{it} because precautionary saving can provide better self-insurance against transitory shocks. ξ_{it} is interpreted as the innovation to higher moments of the income process and captures the innovation to the consumption component that generates precautionary savings and is independent to income.

[11] In the extreme cases of full insurance of income shocks, $\phi_{it} = 0$ and $\psi_{it} = 0$, income shocks do not cause any changes in consumption growth. Also, under the case of no insurance (*i.e.* $\phi_{it} = \psi_{it} = 1$), income shocks have a one-to-one effect on consumption growth.

We assume that the permanent and transitory components of stochastic income evolve by the following processes:

$$y_{it} = P_{it} + v_{it} \tag{3.2}$$

$$P_{it} = P_{it-1} + \zeta_{it}, \quad E(\zeta_{it}) = 0, \quad var(\zeta_{it}) = \sigma^2_{\zeta_{it}} \tag{3.3}$$

$$v_{it} = \varepsilon_{it} + \theta\varepsilon_{it-1}, \quad E(\varepsilon_{it}) = 0, \quad var(\varepsilon_{it}) = \sigma^2_{\varepsilon_{it}}, \tag{3.4}$$

where y_{it} is the stochastic component of income and is assumed to be decomposed into two components that differ in terms of statistical and stochastic properties: a permanent component P_{it} and a transitory component v_{it}.[12] P_{it} and v_{it} evolve as a random walk and MA(1) process, respectively. We assume that ζ_{it} and ε_{it} are *i.i.d.*, and the variance of permanent and transitory shock in each period is potentially allowed to vary over both i and t.

We proceed by estimating equation (3.1) in two steps. The first step is to obtain consistent estimates of γ. As the equation is specified in the first differences, it cancels out any unobserved heterogeneity that is constant over time. However, empirical challenges still remain in the estimation of equation (3.1), and thus the interpretation of γ as wealth effect which captures the causal effect of exogenous wealth changes on the changes in consumption would be problematic. First, changes in wealth are driven by both markets induced price changes and households' consumption-portfolio choices. Because the portfolio selection reflects endogenous optimization of households, γ obtained by regressing ΔC_{it} on Δa_{it} would be inconsistent if we do not hold portfolio selection fixed.[13] Second, there is a possibility that common macro-factors can cause changes in household consumption and asset prices at the same time (**??**), so γ would not indicate the causal effect of wealth changes on consumption growth but simply reflect spurious associations. Finally, measurement errors for wealth are commonly found and result in attenuation bias. Moreover, in the presence of measurement error, biases would be more severe in the case of first difference estimates. In order to handle these empirical challenges, we construct the market-driven housing wealth shock which exploits the differential impact of housing price changes on the household with different amount of wealth held in the form of a house.

[12] y_{it} is derived by running a regression of the log household income for a household i in period t on a set of covariates which include age, squared-age, education, interactions of age and education, household size, number of children, and a full set of month-year dummies and get residuals. Thus, y_{it}, log of real income net of its predictable components,is affected by idiosyncratic shocks.

[13] **?** point out that changes in wealth are divided into two parts: changes in the price of assets and portfolio selection. The asset price changes are exogenous, however, portfolio choices are endogenous.

In the second step, we follow BPP and connect consumption insurance with income shocks. BPP use the predicted residual from the first step estimation and decompose it to identify the differential degree of consumption insurance with respect to the permanent and transitory income shocks. Thus, two different coefficients of consumption insurance can be interpreted as the factor loading measuring the sensitivity of income shocks to consumption growth. However, we allow more heterogeneity than BPP. As many studies address that household assets and savings can be used to manage shocks and insure themselves against shocks (**???**), we allow the households' ability to smooth consumption over income fluctuation to vary with lagged wealth shocks, house ownership and time.

3.3.2 Estimating the Effect of Housing Wealth Shocks on Consumption

This subsection introduces our empirical specification of estimating the wealth effect and explains how to control the potential threat associated with the use of Δa_{it}.

The wealth effect that most of the literature attempt to capture is the changes in consumption with respect to the exogenous changes in wealth. However, some parts of Δa_{it} are driven by exogenous market price changes, holding portfolio constant, and the remainders are caused by endogenous portfolio changes, holding the price of assets fixed. Thus, the use of coefficient on Δa_{it} in equation (3.1) does not imply the effect of exogenous wealth changes on consumption growth and would be biased. In order to attack the challenges mentioned above, we construct the market-induced wealth shock. In particular, we focus on households' assets held in the form of house and housing price changes. Because housing assets take a dominant position in households' wealth, the changes in house price can cause important differential effects on homeowners and non-homeowners.

One concern is that the changes in house price not only just have an effect on housing wealth but also have a similar magnitude of effects on other forms of assets. For instance, house market collapse may have negative effects on the economy, and therefore, it affects not only consumption but also both non-homeowners' and homeowners' overall asset holdings. However, the comparison of changes in asset holdings between homeowner and non-homeowner households with respect to house price show the differential effects. Figure 3.2 compares the nationwide house price index with average changes in net-wealth for homeowners and non-homeowners. The homeowners' asset holdings followed up the changes in house price. In particular, their wealth continued to fall for a period of time after the beginning of the crisis. However, non-homeowner households' wealth continued to recover shortly after the huge decline caused by the crisis. Also, the increase in their asset holdings after the crisis was relatively limited. This supports that although some parts of the variation might be driven by macro factors, the wealth dynamics hugely depends on whether she owns a house or not, and thus housing wealth is suitable to capture the differential effect of changes in house price.

Constructed wealth shock: The constructed wealth shock Z_{it}^H is expressed by the interaction of lagged fraction of lifetime wealth held in housing asset with housing price changes:

$$Z_{it}^H = \frac{\boldsymbol{a}_{it-1}^H}{W_{it-1}} \times \frac{\Delta HP_t}{HP_{t-1}} = \frac{\boldsymbol{a}_{it-1}^H}{W_{it-1}} \times \Delta p_t^H, \tag{3.5}$$

where $\boldsymbol{a}_{it-1}^H$ is lagged value of total housing wealth held by household i, and $\frac{\Delta HP_t}{HP_{t-1}}$ is the percentage change in the Nationwide Housing Price index between the current and previous month approximated by the log difference of the index Δp_t^H.[14] W_{it-1} is a household i's time $t-1$ amount of lifetime wealth which is consisted of period $t-1$ net-asset holdings and the present value of expected future income. The detailed information on W_{it} is explained in Appendix C.1.

The use of Z_{it}^H instead of Δa_{it} has several advantages. First, as the wealth change driven by housing markets holds the amount of housing asset fixed at $t-1$, this allows to separate out the response of consumption caused by households' endogenous portfolio choice and exclude possible correlation with unobserved factors such as changes in borrowing conditions that also affect consumption growth between the corresponding two periods. Second, the nationwide housing market fluctuation is exogenous for each household, and thus the multiplication of Δp_t^H by $\boldsymbol{a}_{it-1}^H$ alleviates the concern about endogeneity between consumption growth and wealth changes. Third, as $\boldsymbol{a}_{it-1}^H \times \Delta p_t^H$ is scaled by W_{it-1}, this rescaling makes it possible to consider the heterogeneity of initial wealth level across households.[15] Thus, the constructed wealth shock depends not only on the absolute magnitude of the impact itself but also on the relative size of the wealth level that an individual holds. Fourth, errors in measuring wealth can be an important source of bias and may lead to underestimation of the true impact of changes in asset holdings (**??**). In this respect,

[14] Our measure of wealth shock is inline with **?**. In order to estimate the causal effect of wealth on health, he suggests stock market driven wealth shock constructed by multiplying the lagged fraction of lifetime wealth held in stocks by percent changes in the S&P 500 stock market index.

[15] For instance, a $10,000 loss might be extremely painful for the poor, however, it has a negligible effect on the choice of the very rich. Moreover, what matter is the expectation that she can earn in the future rather than the amount that she currently possesses at the time of the incident. If she earns a high income and is expected to stay in the labor force for many years in the future, current wealth loss can be sufficiently offset by the expected flow of income (**?**).

the use of constructed housing wealth shock alleviates the problem. Z_{it}^H does not rely on reported wealth changes but uses the level and average price changes, so it alleviates the bias toward zero. Finally, an additional advantage of rescaling by lifetime wealth instead of current wealth is that lifetime wealth has fewer zeros or negative values, which have to be excluded from the analysis.

Because the magnitude of wealth changes depends on not just the amount of asset holdings but lifetime wealth level, if an individual holds 50% of lifetime wealth in the form of housing wealth at period $t-1$, 10% increase in the house price index results in the incidence of 5% positive constructed wealth shock at period t. Figure 3.1 shows the monthly average size of the constructed wealth shock conditional on home-ownership.

Estimating the wealth effect: In order to estimate the causal response of consumption to exogenous wealth changes, we propose and investigate an empirical specification, which regresses consumption growth on the housing market driven wealth shock:

$$\Delta C_{it} = \alpha + \gamma Z_{it}^H + \lambda D_{it-1}^H + \delta \boldsymbol{X_{it}} + \tau_t + \Delta c_{it}, \tag{3.6}$$

where γ measures the effect of the constructed wealth shock on consumption growth. D_{it-1}^H denotes lagged home-ownership dummy, which has the value one if a household i owns a house in time $t-1$ and the value zero, otherwise. τ is a year-month dummy, which controls for possible variations driven by macro-factors.[16]

Our empirical model controls for D_{it-1}^H. Although households take the changes in housing price as random shocks, home-ownership depends on a series of demographic and economic factors (**?**). As households with higher wealth, larger family members, and a higher level of education are more likely to own a house, factors related to house ownership might be correlated not only with the amount of consumption but also with consumption profile over the life-cycle. Therefore, the use of first difference log-transformed consumption can separate out unobserved heterogeneity which does not vary over time, however, it would be insufficient to cancel out potential endogeneity. Thus, we control D_{it-1}^H, and this allows for estimating the effect of housing market shocks on consumption growth controlling for the factors associated with home-ownership.

The estimation of the effect of housing price shocks on consumption growth is implemented mainly by Ordinary Least Square (OLS). We cluster the standard

[16] **?** show that the correlation between consumption and house price is mainly driven by common factors which have an influence on these two variables at the same time.

errors at the level of the household which allows having standard errors that are asymptotically robust to both heteroscedasticity and serial-correlation within households and over time.

Robustness check: We have performed a large number of sensitivity analyses. Our results are robust to various changes in the model specifications.

First, we even specify the model in first differences and newly construct the wealth shock, however, we may be concerned that there remains unobserved household-level heterogeneity that affects both ΔC_{it} and Z_{it}^{H} simultaneously. Thus, equation (3.6) is estimated by fixed-effects estimation. Second, for capturing possible heterogeneity in consumption response to changes in house price for households with different amount of lifetime wealth in the form of housing wealth, D_{it-1} is replaced by $\boldsymbol{a}_{it-1}^{H}/W_{it-1}$. Third, we examine the potential changes in the relation between ΔC_{it} and Z_{it}^{H} if Z_{it}^{H} is not scaled by lifetime wealth. Fourth, households can expect capital gains not only from owning a house but also from stock holdings. Thus, we additionally construct the wealth shock driven by the stock market Z_{it}^{E} and run equation (3.6) together with Z_{it}^{E}. Finally, we include leads and lags of Z_{it}^{H} and check the significance of coefficients on these additional variables. The idea is that households do not respond to future shocks if the wealth shocks are unanticipated. Also, if the coefficient on the past wealth shocks is highly significant, these support the possibility that the wealth shocks have an effect on consumption growth through diverse channels.

The first two robustness checks are provided with main estimation results. The other three results are summarized in Appendix C.2. Also, we investigate the changes in wealth effects caused by the use of different frequency of data sets. One of the advantages of our data set is that it provides households' detailed high-frequency information. If households' consumption and portfolio choices are made at higher-frequency, the estimation results would suffer from aggregation bias when the data are aggregated into different intervals. Thus, we use quarterly and semi-annually data aggregation intervals and estimate causal effects, respectively. The results are also summarized in Appendix C.2.

Anticipated and unanticipated wealth shocks: The nationwide housing market fluctuation is exogenous for each household and would be largely unanticipated. However, the housing market is closely connected with various factors such as business cycle, supply of housing, relative returns of other assets, and real-estate policy, so house price would not be determined in a random manner but partly anticipated using available information. As it is pointed out by **?**, the underlying mechanism of how housing price changes affect the consumption path is different for anticipated and unanticipated ones.[17] Thus, in order to examine the possible differential response of consumption, we decompose the house price changes into anticipated Z_{it}^{H-exp} and unanticipated $Z_{it}^{H-unexp}$ changes.

If households are forward-looking, consumption would not be adjusted at the time of changes in house price and is responding to the time when such a change is anticipated. Thus, they only adjust their consumption if the changes in house price are unanticipated. On the other hand, even if people are forward-looking, the anticipated changes in house price affect consumption if they are facing binding borrowing constraint or capital markets are imperfect. This is because, under the binding credit constraint, the rise in house price causes changes in individuals' behavior only if the capital gains are realized or can be used as collateral to increase borrowing capacity. Also, the response of anticipated house price changes on consumption can be explained by various channels such as a precautionary motive for savings or myopic rather than forward-looking behavior.

In order to distinguish the differential effects of anticipated and unanticipated changes in house price on consumption growth, it is assumed that households form expectations about their housing wealth using the patterns of growth and decline of past changes in the Nationwide House Price Index. Thus, we use the Autoregressive Integrated Moving Average (ARIMA) model for the house price index.[18] An ARIMA model is a statistical model applied to estimate the temporal dynamics of single times series and is consisted of three components: an autoregressive (AR), an integration (I), and a moving average (MA) component. Based on diagnostic tests of autocorrelation (AC) and partial-autocorrelation (PAC) graphs, Akaike Information Criterion (AIC) and Schwarz Criterion (SC), we specify that ARIMA(1,1,1) is the appropriate model to break down the overall house price into expected $E_{t-1}(\Delta p_t^H)$ and unexpected θ_t^H changes.[19] Households' expectation on the house price change is formed by the differences between fitted and previous period log price ($E_{t-1}(\Delta p_t^H) = \hat{p}_t^H - p_{t-1}^H$), and the unexpected innovation is expressed by the differences between the realised house price changes in period t and expected changes formed at $t-1$ ($\hat{\theta}_t^H = \Delta p_t^H - E_{t-1}(\Delta p_t^H)$).

[17] **?** document that if individuals are forward-looking and do not face credit constraints, consumption just responds to unanticipated wealth changes. If households react to anticipated house price changes, they would be myopic or facing binding credit constraints.

[18] **?** also distinguish between expected and unexpected changes in house price. However, they use the housing prices at the municipal level and choose AR(1) model with average house characteristics observed in the municipality.

[19] The augmented Dickey-Fuller (ADF) test with drift shows that the null hypothesis of unit-root in house price index cannot be rejected even at 10% significance level, however, the ADF test result of its first-order difference reject the hypothesis.

The results from the ARIMA model are summarized in table 3.1. Using the estimates of anticipated and unanticipated house price changes, the constructed wealth shock Z_{it}^{H} can be decomposed into two parts: anticipated and unanticipated shocks.

$$Z_{it}^{H} = \frac{\boldsymbol{a}_{it-1}^{H}}{W_{it-1}} \times E_{t-1}(\Delta p_t^H) + \frac{\boldsymbol{a}_{it-1}^{H}}{W_{it-1}} \times \hat{\theta}_t^H = Z_{it}^{H-exp} + Z_{it}^{H-unexp} \tag{3.7}$$

3.3.3 Estimating the Transmission of Income Shocks to Consumption

In this second step, we use the predicted residuals from the first step and investigate the role of housing wealth and the link between income and consumption inequality. We extend *BPP* by introducing more flexible specification. We allow household heterogeneity driven by wealth held in the form of housing wealth to have an effect on consumption inequality. It is assumed that the evolution of the degree of consumption insurance and the variance of income shocks can vary over the previous period house-ownership, lagged wealth shock, and time. Thus, households, which have different exposure to house price shock, respond to the changes driven by the housing market differently.

Our parametric specification of the variance of income shocks, degree of transmission of income shocks to consumption and innovation driven by intrinsic factors of consumption is expressed by:

$$\sigma^2_{\zeta_{it}} = \pi_1^{\zeta} + \pi_2^{\zeta} Z_{it-1}^{H-prev} + \pi_3^{\zeta} D_{it-1}^{H} + \pi_4^{\zeta}\tilde{t} + \pi_5^{\zeta} I_{\{t\geq Jan.1998\}} + \pi_6^{\zeta}\tilde{t} \times I_{\{t\geq Jan.1998\}} \tag{3.8}$$

$$\sigma^2_{\varepsilon_{it}} = \pi_1^{\varepsilon} + \pi_2^{\varepsilon} Z_{it-1}^{H-prev} + \pi_3^{\varepsilon} D_{it-1}^{H} + \pi_4^{\varepsilon}\tilde{t} + \pi_5^{\varepsilon} I_{\{t\geq Jan.1998\}} + \pi_6^{\varepsilon}\tilde{t} \times I_{\{t\geq Jan.1998\}} \tag{3.9}$$

$$\phi_{it} = \pi_1^{\phi} + \pi_2^{\phi} Z_{it-1}^{H-prev} + \pi_3^{\phi} D_{it-1}^{H} + \pi_4^{\phi}\tilde{t} + \pi_5^{\phi} I_{\{t\geq Jan.1998\}} + \pi_6^{\phi}\tilde{t} \times I_{\{t\geq Jan.1998\}} \tag{3.10}$$

$$\psi_{it} = \pi_1^{\psi} + \pi_2^{\psi} Z_{it-1}^{H-prev} + \pi_3^{\psi} D_{it-1}^{H} + \pi_4^{\psi}\tilde{t} + \pi_5^{\psi} I_{\{t\geq Jan.1998\}} + \pi_6^{\psi}\tilde{t} \times I_{\{t\geq Jan.1998\}} \tag{3.11}$$

$$\sigma^2_{\xi_t} = \pi_1^{\xi} + \pi_2^{\xi}\tilde{t} + \pi_3^{\xi} I_{\{t\geq Jan.1998\}} + \pi_4^{\xi}\tilde{t} \times I_{\{t\geq Jan.1998\}} \tag{3.12}$$

where $Z_{it-1}^{H-prev} = \frac{\boldsymbol{a}_{it-1}^{H}}{W_{it-1}} \times \Delta p_{t-1}^{H}$ denotes the lagged constructed wealth shock. In order to reflect possible structural changes caused by the financial crisis, the Regression Discontinuity (RD) design is used for our empirical specification.[20] One

[20] **?** documents that causal inferences from RD designs are potentially more credible than those from typical Difference-In-Difference or instrument variable approaches.

of the advantages of using RD design is that it allows for pooling the separate regression on the cut-off point period, so it is simple and parsimonious (**?**). We set a cut-off point as of January 1998 (*i.e.* $t = 49$). The cut-off point is chosen to reflect the characteristics of our data set consisted of two panels (before-crisis and after-crisis periods) and possible structural changes caused by the crisis. $\tilde{t}$ is a linear time trend, which is normalized by subtracting 49 and dividing 10 ($\tilde{t} = \frac{t-49}{10}$, where $t = 1$ if the period of time is January 1994, $t = 49$ if the period of time is January 1998, and $t = 108$ if t=December 2002). $I_{\{t \geq Jan.1998\}}$ is an indicator function, which has the value one for the observations collected after the crisis period (*i.e.* in or after January 1998) and has the value zero for the before-crisis observations. We also introduce the interaction term between $I_{\{t \geq Jan.1998\}}$ and normalized time trend term $\tilde{t}$ for capturing differences in regression intercept and slope.

Identification of model parameters: The model is identified by imposing covariance restrictions on the process of income and consumption growth. The identification of the idiosyncratic income components and their impacts on consumption follows the discussion in BPP. However, as we introduce more flexibility in the model structure and reflect heterogeneity across households, we use additional moment conditions for getting more precise parameters.

With the assumption on the transitory income shock process (MA(q)) and degree of insurance which just differ between permanent and transitory income shocks, BPP show that income data alone are able to identify the variance of permanent and transitory income shocks. Also, although consumption growth consists of income shocks and consumption insurance, the joint use of household income and consumption data allows for identifying the ability to insure against income shocks. However, as our model allows the income shocks and consumption insurance to depend on variables varying over both i and t, these impose difficulties in empirically estimating the parameters, which govern the ability to insure consumption as well as income shocks precisely. Because the variance and covariances of consumption and income growth just provide the average of income shock variance, these averaging out procedure would result in significant loss of household heterogeneity, and the interaction between the income shocks and degree of insurance causes additional difficulties for parameter identification. Thus, we add the average marginal effects of each time-varying individual covariates in the income shocks and consumption insurance as additional moment conditions. The detail of the moment conditions that we use is presented in Appendix C.3.

Estimation methodology: In order to estimate the vector of unknown data-generating parameters of income shocks and the magnitude of self-insurance in equation (3.8)-(3.12), the Method of Simulated Moment (MSM) strategy is employed. We first stack on the moment conditions explained in Appendix C.3 for the first and second panels as follows:

$$m^j = \begin{bmatrix} m_2^j \\ m_3^j \\ : \\ m_{T_l}^j \\ m_{add}^j \end{bmatrix}, m_t^j = \begin{bmatrix} var(\Delta y_{it}) \\ var(\Delta c_{it}) \\ cov(\Delta y_{it}, \Delta c_{it}) \\ cov(\Delta y_{it}, \Delta y_{it-1}) \\ cov(\Delta y_{it}, \Delta c_{it-1}) \\ cov(\Delta y_{it}, \Delta y_{it-2}) \\ cov(\Delta y_{it}, \Delta c_{it-2}) \end{bmatrix}, m_{add}^j = \begin{bmatrix} E[\partial var(\Delta y_{it})/\partial X_{it-1}^m]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta y_{it-1})/\partial X_{it-2}^m]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta y_{it-2})/\partial X_{it-3}^m]' \\ E[\partial var(\Delta c_{it})/\partial X_{it-1}^m]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it})/\partial X_{it-1}^m]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it-1})/\partial X_{it-2}^m]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it-2})/\partial X_{it-3}^m]' \end{bmatrix}$$

$$j \in \{e, c\} \tag{3.13}$$

where X_{it-s}^m is a vector of household specific variables which govern the income process and consumption insurance. m^e and m^c denote empirical and model based constructed moment conditions, respectively. $l = 1$ ($l = 2$) if the data come from the first (second) panel.

After then, we choose a vector of parameters $\boldsymbol{\beta}$, which minimizes the weighted distance between m^e and m^c:

$$min_\beta \left[m^e - m^c(\boldsymbol{\beta})\right]' \Lambda \left[m^e - m^c(\boldsymbol{\beta})\right], \tag{3.14}$$

where Λ is a weighting matrix, and the elements in the main diagonal of inverse of V are used as Λ ($\Lambda = diag(V^{-1})$). V denotes the variance-covariance matrix of m^e.

In order to get standard errors of MSM estimator, we compute standard errors by:

$$\widehat{var(\hat{\beta})} = \left(M'\Lambda M\right)^{-1} M'\Lambda V \Lambda M \left(M'\Lambda M\right)^{-1}, \tag{3.15}$$

where M measures the sensitivity of the moments to small changes of unknown parameter values ($M = \partial m^c/\partial\beta|_{\beta=\hat{\beta}}$).

3.4 Data

3.4.1 Family Income and Expenditure Survey

Our data set is the Family Income and Expenditure Survey in urban areas of Korea from 1994 to 2002. The survey is the representative consumption survey in Korea which is continuously conducted by Statistics Korea since 1963.[21] Although the survey began in 1963, household-level data have been available only since 1982. It adopts a stratified multi-stage sampling method and surveys around 5,000 households. The data represent Korean households, however, it does not collects household information which resides in rural areas and excludes fishermen, farmers, and one-person household. Households are requested to fill in the family account book with daily income and expenditures, and this information is input directly by the households. Each household's recorded daily diary is complied on a monthly basis.

The Korean household data have a number of useful features and allow us to overcome several empirical challenges facing other household survey data such as the CEX or PSID. Each household is covered over 12 to 60 months, so our sample consists of two panels, which cover before the crisis (January 1994 - December 1997) and after the crisis (January 1998 - December 2002) periods. Also, the data set has long monthly panels, so it provides detailed high-frequency information.[22] The high-frequency nature of the panel is important in our context because data at annual frequency are likely to suffer from aggregation bias if consumption decisions are made at a higher frequency.

In particular, it contains rich information on household consumption and income of main household members. The consumption expenditure data contain detailed categories, not just food consumption, and durable consumption expenditure is also available. For instance, the data used in BPP are synthetic panel data by combing the PSID that contains income and food expenditure, and CEX that contains expenditures on non-durables but lack of reliable income variables. They impute household consumption of the PSID households from their expenditure on food and the pattern of household non-durable expenditures from CEX. The imputation errors can cause bias in the estimation of the variance of transitory components. And if the imputation errors are correlated with the income growth of the past, current, and future, then they also lead to bias in the estimation of partial

[21]The data have been widely used by researchers and policy-makers which result in a diverse range of publications (**??????**).

[22]Between 1968 and 1997, PSID conducted an interview every year. Since then, interviews have been biennial.

insurance parameters. Moreover, as the sample period covered the Asian financial crisis, it allows us to examine the relation between the changes in household wealth and consumption growth and households' consumption response to income driven shocks.

Sample selection: The head of household is defined as a person who represents the household substantially and is responsible for the living. Based on the definition, we start with 10,481 households and 301,692 household-month observations. In order to avoid abrupt drastic changes in the composition of households, a household and its entire observations are dropped from the sample if it cannot satisfy any of the following two criteria: (1) a household (HH) experiences changes in the head of household across the period, and (2) a HH head's age is under 25 or older than 60. These reduce the number of households and observations in the sample to 8,087 and 215,895, respectively.[23] After then, we do not use 4,193 monthly observations (4 households) whose income is higher than the top 1% and lower than the bottom 1%. Finally, we additionally exclude income outliers' 6,007 monthly observations whose monthly real income growth rate is greater than 500% or less than -80%. The final sample is composed of 209,888 monthly observations and 8,083 households (see table 3.2).[24]

Definition of consumption and income: We use categories to construct consumption and income measures as close as possible to the ones used by **?**. This study defines consumption as non-durable expenditure which is collected by households recording a diary of expenditure. Our measure of consumption spending includes the sum of food (both at home and out of home), alcohol, tobacco, public and private transportation, personal care, entertainment and expenditure on housing and utilities such as water, sewage, service, and heating fuels. With regard to income, we first derive taxable family income, which is composed of household labor income (include salary and bonus), business income, income from financial assets (the sum of interest, dividend, rent, and other property earnings), and public transfer excluding tax refund.[25] In order to derive the measure of income used in

[23] As the data do not provide information about identifying each member in the family if a household head's age does not increase by up to one year in each month (*i.e.* $\Delta Age_{it} < 0$ or $\Delta Age_{it} > 1$) or a HH head's gender varies across time, the household is regarded as experiencing changes in the head of household and excluded from the sample.

[24] 97,424 monthly observations and 4,022 households belong to the period before 1998, and 112,464 observations and 4,061 households belong to the period after-crisis.

[25] In Korea, transfer income in the data includes yearly tax refund. Considering the fact that 97% of transfer occurs in February, March, or April., and these correspond to the period when government pay income tax refund. Many people in Korea regard this tax refund as a kind of

this study, we exclude both incomes from financial assets and taxes on labor and business income. Also, all the monetary variables are deflated by the monthly CPI of December 2000.

3.4.2 Measuring Household Wealth

Family Income and Expenditure Survey provides rich detail of information on financial flows of households, however, one of the limitations is that we cannot observe the amount of wealth directly. Thus, we follow **?** and construct the household wealth using the information of account-level data on a diverse kind of asset holdings as well as its transactions. The following equation decomposes the changes in wealth into two parts: portfolio selection and price changes (or capital gains).

$$\boldsymbol{p_t} A_{it} - \boldsymbol{p_{t-1}} A_{it-1} = \sum_k \boldsymbol{p_t^k} A_{it}^k - \sum_k \boldsymbol{p_{t-1}^k} A_{it-1}^k = \tag{3.16}$$

$$\underbrace{\sum_k \boldsymbol{p_t^k}(A_{it}^k - A_{it-1}^k)}_{\text{Portfolio Selection}} + \underbrace{\sum_k A_{it-1}^k(\boldsymbol{p_t^k} - \boldsymbol{p_{t-1}^k})}_{\text{Price Changes}}$$

where A_{it} and $\boldsymbol{p_t}$ denote a vector of household i's period t net-assets and their prices consisted of k different types of assets. The first term in the second line of equation (3.16) is changes in wealth due to portfolio selection, and the second term is wealth changes caused by price change, holding portfolio constant. These imply that we directly use the financial instrument and real-estate transactions to derive household wealth, and its changes come from investment choice and asset price movements. For notational simplicity, let $a_{it}^k = \boldsymbol{p_t^k} A_{it}^k$ and $a_{it} = \boldsymbol{p_t} A_{it}$ henceforth.

Portfolio selection: The portfolio selection records all types of household-level asset transactions, inflows as well as outflows and is measured by the sum of new asset purchases and loan repayments less sales of assets and new-loans. Purchase of assets consists of the increase in bank deposits, paying deposits into the instalment savings plan, payment of saving insurance plan premium, mutual fund purchase, purchasing securities, real-estate, or precious metal, deposit payment, and all other purchases of assets. Loan repayments include all types of principal repayment in

bonus, so even public service broadcasts and news-papers call this tax refund as the 13th income (because individuals receive salary every month (12 months), the regular tax refund is regarded as one kind of income). In order to relieve the distortion caused by the tax refund, it is assumed that an equal amount of tax refund is given every month.

addition to the refund of the housing deposit. Sales of assets record the withdrawal of savings, amount of insurance claim, private or retirement pension payments, sales of equity, deposit reclaim, real-estate sales, and sales of all other forms of assets. Finally, the new loans include all forms of loans regardless of their purpose.[26]

Capital gain: We divide household wealth a_{it} into five main categories: housing wealth a^H_{it}, housing deposits a^{HD}_{it}, savings a^S_{it}, equity a^E_{it}, and all other $k-4$ types of assets $\sum_{k\neq H,HD,S,E} a^k_{it}$. If all components in equation (3.16) are observed, the capital gains can be computed directly from data. However, due to the data limitation on the availability of variables, the following assumptions are imposed to measure the amount of assets held by each household: 1. House owners and equity holders expect capital gains from living at their own house $A^H_{it-1}(\boldsymbol{p^H_t} - \boldsymbol{p^H_{it-1}})$ and equity holdings $A^E_{it-1}(\boldsymbol{p^E_t} - \boldsymbol{p^E_{it-1}})$, however, the other types of asset holders cannot expect benefits from changes in the price of their asset holdings (*i.e.* $\sum_{k\neq H,E} A^k_{it-1}(\boldsymbol{p^k_t} - \boldsymbol{p^k_{t-1}}) = 0$), and 2. Price changes are approximated using aggregated index growth (Nationwide House Price Index and Korea Composite Stock Price Index (KOSPI)).[27] Following the assumptions, equation (3.16) can be rewritten as equation (3.17):

$$\begin{aligned}\Delta a_{it} = &\sum_k \boldsymbol{p^k_t}(A^k_{it} - A^k_{it-1}) + \boldsymbol{A}^H_{it-1}(\boldsymbol{p^H_t} - \boldsymbol{p^H_{t-1}}) + \boldsymbol{A}^E_{it-1}(\boldsymbol{p^E_t} - \boldsymbol{p^E_{t-1}}) = \\ &\sum_k \boldsymbol{p^k_t}(A^k_{it} - A^k_{it-1}) + \boldsymbol{a}^H_{it-1}\frac{\Delta \boldsymbol{p^H_t}}{\boldsymbol{p^H_{t-1}}} + \boldsymbol{a}^E_{it-1}\frac{\Delta \boldsymbol{p^E_t}}{\boldsymbol{p^E_{t-1}}}\end{aligned} \tag{3.17}$$

Level of initial wealth: Although we need to capture the exposure to financial and real-estate market fluctuations, the data set does not provide the amount of asset holdings and liabilities except for the housing deposit. Once we get the initial level of wealth and its components, however, it is possible to derive the amount of wealth after the initial period consecutively. Following the categorization of

[26]For instance, if an individual took out a loan of one million dollars from a bank and used it to buy a house at period t. At time $t+1$, his real-estate price had risen by 100%, and he paid 0.1M in mortgage interest by selling his equity. These transactions are recorded as follows: In time t, the new loans and asset purchases increased by \$1.0M, respectively, so these transactions did not cause the changes in the amount of net-assets but caused the changes in the composition of asset holdings. In time $t+1$, the sales of assets increased by 0.1M, and capital gain was 1.0M. This implies that interest payments are not directly recorded as a transaction of assets but indirectly captured by a decrease in asset holdings to finance mortgage interest. In the end, his net-asset holdings eventually increased by \$0.9M at the end of time $t+1$.

[27]As the money value of debts remains unchanged across two adjacent periods, capital gains on housing wealth and equity result not from net-assets, but from the corresponding total amount of asset holdings (*i.e.* If $\boldsymbol{p^{\{\cdot\}}_t}\boldsymbol{D}^{\{\cdot\}}_{it-1} = \boldsymbol{p^{\{\cdot\}}_{t-1}}\boldsymbol{D}^{\{\cdot\}}_{it-1}$, then $A^{\{\cdot\}}_{it-1}(\boldsymbol{p^{\{\cdot\}}_t} - \boldsymbol{p^{\{\cdot\}}_{t-1}}) = \boldsymbol{A}^{\{\cdot\}}_{it-1}(\boldsymbol{p^{\{\cdot\}}_t} - \boldsymbol{p^{\{\cdot\}}_{t-1}})$, where the bold $\boldsymbol{A}^{\{\cdot\}}_{it}$ and $\boldsymbol{D}^{\{\cdot\}}_{it}$ denote total amount of asset holdings and corresponding debts, respectively).

household wealth, the first observation of net initial-assets a_{i0} can be written by equation (3.18):

$$a_{i0} = \sum_k a_{i0}^k = a_{i0}^H + a_{i0}^{HD} + a_{i0}^S + a_{i0}^E + \sum_{k \neq H,HD,S,E} a_{i0}^k \tag{3.18}$$

In order to construct the initial period wealth, we use each household's first observation of monthly income from corresponding assets as well as interest payments on liabilities and divide these variables by pre-crisis period monthly real interest rates $\overline{r}$ set as 0.693%.[28,29] In particular, the initial period housing total wealth $\boldsymbol{a}_{i0}^H$ is approximated by dividing the imputed real monthly rent which a house owner needs to pay for living in his own house or similar property by monthly $\overline{r}$. With regard to the initial period total housing deposit $\boldsymbol{a}_{i0}^{HD}$, South Korea has a unique housing rent system called 'Jeonse'. Instead of paying monthly rent, a renter using the Jeonse system makes a lump-sum deposit to the house owner, and the amount is usually 50%-90% of the market value of the house. Also, the renter gets the housing deposit back at the contract termination date. Thus, if a household is living in a Jeonse rented house, its housing deposit is needed to be regarded as a component of the renter's wealth, and we regard the initial observation of Jeonse renter's housing deposit as the amount of housing deposit.[30,31]

Validity of household wealth construction results: Figure 3.3 and table 3.3 show the wealth construction results. The figure compares the constructed total housing wealth with the Nationwide House Price Index. The constructed housing wealth appropriately captures changes in the actual house price. With regard to

[28] The nominal interest rate is set by using 3-month or 90-day rates of Certificates of Deposit for the Republic of Korea" provided by FRB of St. Louis (FRED) and adjusted by the consumer price index. After then, monthly $\overline{r}$ is derived by averaging it between 1994-1997.

[29] As interest from savings and dividends are usually paid based on a specific time period, we use the average of each household's observed first-year interest income and dividends scaled by monthly $\overline{r}$ as $\boldsymbol{a}_{i0}^S$ and $\boldsymbol{a}_{i0}^E$, respectively. Also, the initial value of other types of assets $\sum_{k \neq H,HD,S,E} a_{i0}^k$ is measured using asset income excluding interest income and dividend.

[30] 59% and 28% of observations in our sample are their own house and use 'Jeonse', respectively. 10% are paying monthly rent. The remainder of the households is living in either a company house (1%) or a free house (2%).

[31] It could be possible that a person owns a house and rents out his house at the same time. This case implies that she rents a house from another person and puts down a housing deposit. However, just 0.02% of observations in the sample have a positive housing deposit and own house simultaneously. Moreover, if a house owner rents out a house and uses the housing deposit that she receives from the renter as the deposit for renting another house to live in, it would be difficult to separate out the individual's actual amount of wealth. Thus, it is assumed that a household's housing wealth is equal to imputed housing rent divided by $\overline{r}$ if it owns a house, and $\boldsymbol{a}_{it}^H$ has the value zero, otherwise. In the case of a housing deposit, the reported housing deposit is regarded as $\boldsymbol{a}_{it}^{HD}$ only if the household reports that it rents a house using Jeonse system.

the table, the first column summarizes the composition of household total asset holdings in our sample, and the second column shows the share of corresponding asset components from the Korean Household Panel Study (KHPS).[32] Although households in the sample hold a relatively higher proportion of their assets in the form of housing wealth and have a relatively smaller share of financial assets, our sample well reflects overall patterns in asset holdings of Korean households.

3.5 Estimation Results

3.5.1 Predictive Power of Constructed Wealth Shock

Before we estimate the effect of the constructed wealth shock on consumption growth, we first explore whether our constructed wealth shock is an appropriate measure to predict the changes in actual scaled wealth. Thus, this subsection examines the relationship between the constructed wealth shock and actual scaled wealth change expressed by equation (3.19):

$$\frac{\Delta a_{it}}{W_{it-1}} = \beta_0 + \beta_1 Z_{it}^H + \beta_2 \frac{a_{it-1}}{W_{it-1}} + \pi X_{it} + \nu_{it} \tag{3.19}$$

where X_{it} includes the same control variables used in our main empirical strategy and a full set of month-year dummies.

Table 3.4 summarizes the predictive power of our constructed wealth shock. All specifications control the same X_{it}. The results show that regardless of model specification, the constructed wealth shock has a high predictive power to explain the changes in the amount of net-asset holdings. Column 1 shows that the regression yields a strongly positive effect of constructed wealth shock on the changes in the actual amount of net-asset holding, and the coefficient is statistically significant at 1% level. The estimated coefficient implies that the constructed positive wealth shock of 10% is associated with changes in $\frac{\Delta a_{it}}{W_{it-1}}$ by 9.3%. Looking more closely, because the average value of representative owner-occupiers' housing wealth accounts for 23.7% of their lifetime wealth, a 10% increase in the nationwide house price inflation is associated with 2.2% increase in their scaled wealth.[33] The results in column 2 use the same covariates as column 1, however, the coefficients are gained from fixed effect estimation. The regression also yields a highly significant coefficient of about 0.945.

[32] Although the major interest of this section is focused on the construction of net-assets, table 3.3 reports the total amount of asset-holdings for the purpose of examining the validity of the method that we adopt.

[33] $2.20\% = 23.74\% \times 10\% \times 0.925$

In column 3, the constructed wealth shock is substituted by a lagged dummy for house ownership multiplied by the growth of the house price index, $D^H_{it-1} \times \Delta p^H_t$. Also, in order to control for the effect of changes in housing wealth through a more flexible way, the house price index growth rate Δp^H_t is additionally controlled. The estimated coefficient on $D^H_{it-1} \times \Delta p^H_t$ is 0.224, and thus the magnitude of the effect of housing price change under specification (3) is equivalent to that under specification (1). Also, the coefficient on Δp^H_t is small in magnitude and statistically insignificant. This implies that if a household does not own a house, the nationwide housing price change just has a limited effect on the wealth of non-homeowners. Column 4 introduces two dummies for capturing the possible changes in the magnitude of the wealth shock on $\Delta a_{it}/W_{it-1}$ before and after the crisis periods. Before the crisis, the positive effect of constructed wealth shock on net-wealth is 0.880, and the magnitude of the effect becomes 0.927 after the crisis. Also, the explanatory power of the scaled amount of lagged wealth is small and insignificant in all four specifications.

3.5.2 Effect of Housing Market Shocks on Consumption

One of the major interests in this study is how sensitive consumption growth is to the market-induced wealth shock, and whether the anticipated and unanticipated wealth shock have a different consumption impact when we control for standard control variables. The estimation result is summarized in table 3.5. The first column regresses consumption growth on constructed wealth shock via OLS. Due to the possible endogeneity, we also control for D^H_{it-1}. Instead of controlling D^H_{it-1}, regression in column 2 controls lagged fraction of housing wealth scaled by lifetime wealth $\frac{a^H_{it-1}}{W_{it-1}}$. In order to reflect potential heterogeneity across households, column 3 estimate the parameters by the fixed-effect method. Column 4 divides Z^H_{it} into Z^{H-exp}_{it} and $Z^{H-unexp}_{it}$, and these effects are estimated by OLS.

The housing wealth effect in empirical literature has a wide range of values. In this study, regardless of specifications, the regressions in column 1-3 of the table yield a positive wealth effect. The estimated coefficients are ranging between 1.886 and 2.453 and all statistically significant at 1% level. In column 1, the estimated effect of constructed wealth shock on consumption growth is 1.886. Column 2 shows that replacing D^H_{it-1} with $\frac{a_{it-1}}{W_{it-1}}$ does not cause large changes in the estimated magnitude of wealth effects. A positive 1% wealth shock is associated with 1.95% consumption growth. The fixed effect regression results are reported in column 3 and show that the magnitude of the effect of Z^H_{it} on consumption growth is greater than that of OLS estimation.

The implication of the estimated coefficient under column 1 is evaluated at the mean of $\frac{\boldsymbol{a}_{it-1}^H}{W_{it-1}}$ because the constructed wealth shock depends not only on changes in the house price but also on scaled housing wealth. During the sample period, the average of scaled housing wealth and non-durable monthly consumption was 0.24 and \$848 (0.93 million KRW), respectively.[34] Thus, a 1% increase in the nationwide house price index leads to a rise in monthly consumption by \$3.80, which is equivalent to 0.45% of the non-durable consumption.[35] In particular, the average of conditional constructed lagged wealth shock of people who own a house records the lowest of -0.62% ($\Delta p_{March\,1998} = -2.83\%$ and average of conditional scaled lagged housing wealth = 0.219) in March 1998, and thus the wealth shock in March 1998 causes a decrease in consumption by 1.165%.

Relative to existing empirical studies, our wealth effect estimate is neither exceptionally low nor high and comparable with other studies such as **?** and **?**. Unlike our study, these two papers regress the first difference of log consumption on that of log house price, so our real wealth effect is needed to be multiplied by home-owners' average of $\frac{\boldsymbol{a}_{it-1}^H}{W_{it-1}}$ for the sake of comparability. **?** find that the estimated coefficient for the U.K. is between 0.651 and 1.705 depending on whether the model controls the interaction of cohort and home-ownership dummies. In all specifications, their estimated coefficients on changes in regional house price are significant at 1%, and comparing it with our estimated magnitude ranging between 0.448 and 0.582, the effect is about 1.12-3.81 times larger.[36,37] **?** find that the estimated wealth effect is 0.08 for Denmark, which is much smaller than our estimates.[38]

Column 4 shows the estimation result of splitting the constructed wealth shock into anticipated and unanticipated parts. The response of consumption to anticipated and unanticipated changes in housing wealth is 1.599 and 2.646, respectively. These coefficients are statistically significant at 1% level and indicate that household sensitively responds not only to the unanticipated but also anticipated changes in housing price. The effect of a 1% positive increase in anticipated and unanticipated

[34] One U.S. dollar is equivalent to about 1,100 KRW.

[35] If we assume that a 1% increase in house price occurs in the first month of a given year, and there are no more house price changes in the remaining months, then a one-time increase in housing wealth causes an increase in annual consumption by \$45.5 which is smaller than the amount of increase in consumption by \$94.5 suggested by **?**.

[36] Using the coefficient on Z_{it}^H under the specification (1), 0.448 is derived by multiplying the coefficient 1.886 by the home-owners' conditional average of $\frac{\boldsymbol{a}_{it-1}^H}{W_{it-1}}$.

[37] **?** use data from a time-series of cross-section, so the huge magnitude of wealth effect would be partly caused by the data limitation.

[38] **?** document that due to endogeneity problems, the estimate cannot be directly interpreted as a housing wealth effect.

house price inflation evaluated at the mean of $\frac{a^H_{it-1}}{W_{it-1}}$ is associated with 0.38% and 0.63% changes in consumption. The results are corresponding to the hypothesis of the collateral channel from housing wealth; an increase in anticipated housing wealth change allows borrowing constrained home-owners to consume more through loosening lending constraints.

The estimated anticipated and unanticipated wealth effect in this study is larger than previous studies such as **??**. **?** use the Italian Survey of Household Income and Wealth and report that the estimated coefficients on both anticipated and unanticipated changes in housing wealth are positive and significant. The consumption sensitively reacts to anticipated housing wealth gain comparable to wealth shock driven by unanticipated house price. They report that a 1% increase in anticipated and unanticipated housing wealth is associated with 0.034% and 0.030% changes in consumption growth. (**?**) report that the estimated coefficients on anticipated and unanticipated house price shock are 0.022 and 0.003, respectively. However, these coefficients are not significant.

3.5.3 Estimation of Consumption Insurance

This subsection focuses on the degree of permanent ϕ_{it} and transitory ψ_{it} consumption insurance with respect to the corresponding income shocks, and the way that consumption insurance and income shocks are influenced by changes in households' wealth held in the form of house. To do this, we present three empirical specifications for capturing the degree of transmission of income shocks to consumption. The specification that controls the effect of constructed lagged wealth shock Z^{H-prev}_{it-1}, lagged house ownership D^H_{it-1}, time-related variables (after-crisis dummy $I_{\{t \geq Jan.1998\}}$, normalized linear time trend $\tilde{t}$ and interaction between $\tilde{t}$ and $I_{\{t \geq Jan.1998\}}$), and household head's age Age_{it} serves as the baseline.[39] For the purpose of checking the robustness of the estimation result, we additionally investigate two alternative specifications. The Second model specification is equivalent to the baseline except for controlling $Z^{H-cumul}_{it-1}$ defined by the multiplication of lagged scaled housing wealth by three-month cumulative house price change between $t-1$ and $t-4$ instead of Z^{H-prev}_{it-1}. This alternative specification is introduced for capturing possible delayed response driven by house price changes. In order to check the robustness of our baseline results, the third specification just controls both time-related variables and D^H_{it-1}.

[39]Each household head's age is controlled for reflecting possible changes in the ability to smooth consumption with respect to shocks of different durability at different stages of lifetime.

Table 3.6 reports the estimated parameters under three different specifications. Panel 1 shows the estimation results under the baseline specification. Panel 2 and 3 report the estimates under the second and third model specification. Regardless of model specifications, the table provides that there are considerable differences and household heterogeneity in the ability to smooth consumption over both permanent and transitory income fluctuation, and the degree of insurability significantly relies on housing wealth. The estimated parameters on Z^{H-prev}_{it-1} (or $Z^{H-cumul}_{it-1}$) and D^{H}_{it-1} of consumption insurance against permanent and transitory income shocks are highly significant and imply that non-homeowner households have less ability to self-insure even transitory income shocks. Panel 1 and 2 consistently report that an increase in house price is associated with better ability to income fluctuation driven by permanent component, and the coefficient is significantly different from zero. A 1% increase in the monthly and three-month cumulative house price is associated with a decrease in the effect of the permanent income shock and can be translated into movements in the consumption growth by -0.013 and -0.003, respectively.[40] On the other hand, the effect of the wealth shock on ψ is limited. Although the estimated coefficient on Z^{H-prev}_{it-1} of ψ under the baseline is positive and significant, its magnitude is far smaller than that of the permanent one, and the sign of the parameters is even changed and insignificant under the specification (2).

Panel 1 provides that the estimated parameters on D^{H}_{it-1} of ϕ and ψ are -0.93 and -0.10, respectively. The estimated magnitude of corresponding estimates under specification (2) is equivalent to the results under the baseline and consistently report the positive relation between home-ownership and the ability to insure consumption against income shocks. However, specification (3) overstates (understates) the absolute magnitude of the effect of lagged house ownership on ϕ (ψ). With regard to the possible structural changes, the baseline and specification (2) report that around 20% more permanent shock to consumption is insurable after the crisis, and the coefficient on $I_{\{t \geq Jan.1998\}}$ is significant at 10% level. However, the coefficient on the normalized linear time trend is not significant, and there is no clear evidence of changes in the slope of time trend before and after the crisis (*i.e.* The coefficients on $\tilde{t}$ and $\tilde{t} \times I_{\{t \geq Jan.1998\}}$ of ϕ and ψ are insignificant.). We also find that the ability of insurance increases with age, however, the magnitude of the effect of Age_{it} on ϕ is small and insignificant. This is consistent with previous literature such as **??** which do not support a significant age trend in ϕ.

Figure 3.4 shows the monthly average of estimated consumption insurance and the variance of income shocks under the baseline model. Panel (a) of figure 3.4 shows that the estimated average transmission of permanent and transitory income

[40] $-0.013 = -0.055 \times 1\% \times 23.7\%$ and $-0.003 = -0.012 \times 1\% \times 23.7\%$

shocks to consumption growth corresponds to the argument of partial insurance supported by **???**.[41] Also, the results are in accordance with a simple permanent income hypothesis (PIH): only permanent income shocks induce substantial changes in consumption, and transitory income shocks should not alter consumption much. In other words, a simple PIH suggests that the effect of transitory shocks on consumption is smoothed more than that of permanent ones, so ϕ should be greater than ψ. Panel (b) provides the answer to the question of what is the main reasons for the sudden hike and gradual decline in income inequality $var(\Delta y)$ since it increased greatly right after the crisis. The changes in the variance of income growth are mainly driven by the sudden increase in transitory shocks, and the decrease in permanent shocks also contributes to the decline in income shocks.

Row 1 in table 3.7 shows that the average estimated consumption insurance against permanent shocks is 0.633, which is around 4.6 times greater than that of ψ (0.136).[42] These imply that 36.7% and 86.4% of permanent and transitory shocks to consumption are insurable. The results are qualitatively inline with previous studies. For instance, BPP find that the ability to insure consumption against income risks in the U.S. is imperfect, and 35.8% and 94.7% of permanent and transitory components of income shocks are insurable, respectively. **?** choose a lifecycle model and compare how the degree of consumption insurance in the U.S. changes depending on borrowing constraint. Under the natural borrowing constraint, around 22% and 94% of permanent and transitory components of income shocks are insurable, however, the ability to insuring permanent and transitory shocks decrease to 7% and 82% under zero borrowing condition.

Also, since the financial crisis, the ability to insure consumption against income shocks has been improved. Before the crisis, the estimated average ϕ and ψ under the baseline are 0.685 and 0.150, respectively. After then, these figures become 0.592 and 0.125. The results appropriately reflect the changes that occurred after the financial crisis: the rapid rebound of the housing market after experiencing a huge drop and the improvement in households' access to financial markets after the crisis. Moreover, row 2 and 3 of the table provide that the substitution of Z_{it-1}^{H-prev} by $Z_{it-1}^{H-cumul}$ or exclusion of Z_{it-1}^{H-prev} and demographic factor (Age_{it}) do not change the results much. These show the robustness of our results, and the use of different model specification just marginally changes the size of estimated ϕ and ψ.

[41] *i.e.* The estimated consumption insurance with respect to permanent and transitory income shocks is smaller than one.

[42] The average of estimated $\hat{\phi}$ is derived by $\bar{\hat{\phi}} = \frac{1}{NT}\Sigma_t^T \Sigma_i^N \phi_{it}$, where N is the number of households, and T is the number of months in the sample. The estimated average consumption insurance with respect to transitory shock is 0.136.

Figure 3.5 compares the actual variance, covariance, and auto-covariance of income as well as consumption growth (dotted line) with their predicted values (solid line) under the baseline specification.[43] In general, the model well captures the target moments that we use to estimate the parameters. The constructed moment conditions properly replicate the changes in income and consumption fluctuation, their covariance, and auto-covariance.

3.5.4 Implications on Consumption Inequality

In this subsection, we decompose the consumption growth unexplained by demographics to quantify the relative importance of the degree of consumption insurance, income shocks, innovation to consumption, and unanticipated wealth shock in explaining changes in the variance of consumption inequality. Wealth shocks influence consumption inequality in three ways, and these channels can be quantified as:

(1) Direct effect on ΔC_{it} by unanticipated wealth shock Z_{it}^{unexp} in the term λZ_{it}^{unexp}.

(2) Through effect on income shock driven unexplained consumption growth Δc_{it}. There are two sub-channels: (2a) through the influence on the insurance parameters ϕ_{it} and ψ_{it}; (2b) through the correlations with the variance of the permanent and transitory income shocks $\sigma^2_{\zeta_t}$ and $\sigma^2_{\xi_t}$.

(3) Through effect on unexplained risk premium ξ_{it}.

Let consumption growth unexplained by demographics be $\vartheta_{it} = \Delta c_{it} + \lambda Z_{it}^{unexp}$. If the unanticipated wealth shock is absent from the first stage regression of consumption, ϑ_{it} would be the unexplained consumption.

$$\begin{aligned} \vartheta_{it} &= \gamma Z_{it}^{unexp} + \Delta c_{it} = \Delta C_{it} - \alpha - \gamma Z_{it}^{H-exp} - \lambda D_{it-1}^{H} - \delta \boldsymbol{X_{it}} - \tau_t \\ &= \gamma Z_{it}^{unexp} + \phi_{it}\zeta_{it} + \psi_{it}\varepsilon_{it} + \xi_{it} = \gamma Z_{it}^{unexp} + \Delta c_{it}^{I} + \xi_{it} \end{aligned} \tag{3.20}$$

Consumption inequality can be expressed by:

$$var(\vartheta_{it}) = \underbrace{\gamma^2 var(Z_{it}^{unexp})}_{\text{channel 1}} + \underbrace{var(\Delta c_{it}^{I})}_{\text{channel 2}} + \underbrace{var(\xi_{it})}_{\text{channel 3}} \tag{3.21}$$

Using the estimated coefficients summarized in column 1 of table 3.6 and the coefficient on Z_{it}^{H} in column 1 of table 3.5, the changes in $var(\vartheta_{it})$ can be decomposed

[43] Although we do not provide the overall fitness of the estimation results under the specification (2) and (3), the alternative specifications also well capture the actual variance, covariance, and auto-covariance of income and consumption growth. The results can be provided upon request.

by the contribution of each factor as follows:

$$\Delta var(\vartheta_{it}) \approx \gamma^2 \Delta var(Z_{it}^{H-unexp}) + var(\zeta_{it})\Delta\phi_{it}^2 + \Delta var(\zeta_{it})\phi_{it-1}^2 \\ + var(\varepsilon_{it})\Delta\psi_{it}^2 + \Delta var(\varepsilon_{it})\psi_{it-1}^2 + var(\xi_{it}), \tag{3.22}$$

The result of the decomposition is summarized in table 3.8. A prominent pattern in $var(\xi_{it})$ is its decreasing trend. The flat $var(\vartheta_{it})$ over time in the presence of increases in the variance of income and wealth shocks is largely because of the shrinking $var(\xi_{it})$. During the crisis and the subsequent recovery, macro risk is elevated relative to idiosyncratic risk. The risk on the future income and wealth increased in common, and the risk premium is better captured by the time dummy or demographic variables. As a result the crisis reduces the heterogeneity in the unexplained risk premium. This dynamics in the risk premium is not captured by the variance of permanent and transitory idiosyncratic income shocks and the wealth effects. Development in credit market may have contributed to the shrinking $var(\xi_{it})$.

Overall the model fits the time series of cross-sectional moments of income and consumption growth quite well. Income inequality jumped during the Asian Financial Crisis and dropped as the crisis ended, while wealth suffered a significant loss at the crisis and recovered after the crisis. Throughout the crisis and recovery, consumption inequality stayed flat with the response to income shocks trending downwards over time. The downward trend in consumption response to income may be partly due to the working of a combination of wealth effects. During the crisis, wealthy households suffered disproportionately loss in financial wealth. The wealth effect resulted in wealthy household's cuts in consumption, which helped to reduce the cross-sectional variance in consumption. The credit market froze at the crisis, which hurt the less wealthy households. Consumption and consumption inequality of the less wealthy group tracked income and income inequality more closely. The wealthy households' do not rely on the credit market for consumption smoothing so their consumption was not more closely tracking income during the crisis than before the crisis. As the financial and housing markets recovered, both wealthy and less wealthy households sharply raised consumption for reasons contrary to those explained above. Another contributing factor for the post-crisis increase in consumption of less wealthy households was the more widespread adoption of the credit card. The combination of these developments in the asset markets made household consumption less responsive to household income shocks.

3.6 Conclusion

In this paper, we use high-frequency Korean household-level panel data with comprehensive information on consumption, income, and wealth and estimate the response of household consumption to the household wealth held in the form of a house. Also, we extend the analysis of the housing wealth effect from the consumption growth to the consumption inequality and its covariance with the income shocks.

We take two steps to empirically analyse the wealth effect on consumption growth and its inequality. First, we obtain consistent estimates of the wealth effect on the mean of consumption growth, exploiting the differential effect of the housing price change on households with a different fraction of remaining lifetime wealth held in the form of a house. The use of the constructed wealth shock allows us to control endogeneity and reduce the attenuation bias problem. Second, we decompose the residual consumption growth from the first step estimation to identify the component of income shocks and consumption insurance parameters. As we introduce more heterogeneity and allow for differential consumption response varying on time, household wealth, and exogenous housing market-driven wealth shocks, our model quantifies the relative importance of household wealth in explaining changes in consumption inequality.

We find that constructed wealth shock has a positive and significant effect on consumption. A 1% increase in the nationwide house price index causes a rise in monthly consumption by 0.45% on average. Moving on to the transmission of income shocks to consumption inequality, the estimated consumption insurance with respect to the permanent and transitory income fluctuation is smaller than one. On average, 86.4% of transitory income shock can be insurable, however, 63.3% of permanent income shock is transmitted to the consumption growth. Also, we find that a 1% increase in house price is associated with the improvement in consumption insurance against permanent income shock by 0.013%. The results show that there is a large degree of differences in the ability to insure consumption against income shocks, and these differences are caused by the heterogeneity of the household wealth held in the form of the house.

Figure 3.1 Conditional Average of Constructed Wealth Shock of House Owners

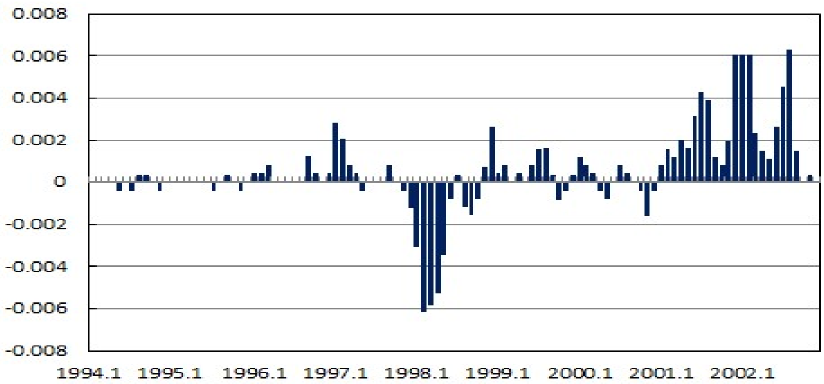
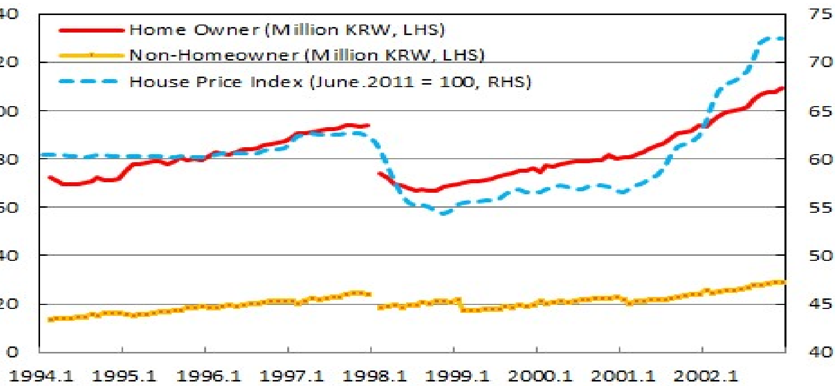
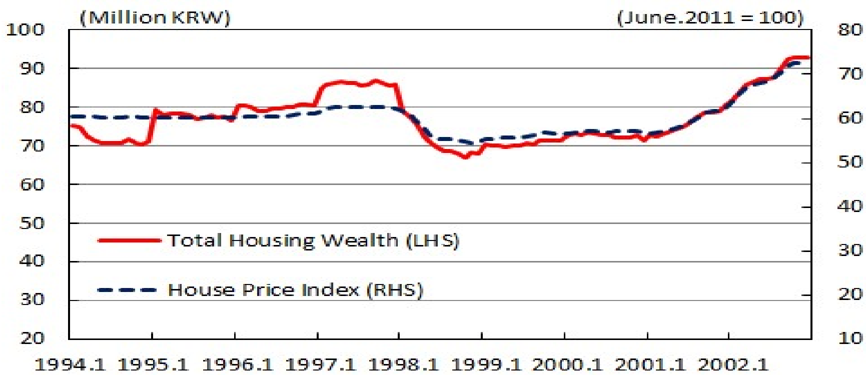


Figure 3.2 House Price Index and Changes in Wealth by Home-ownership



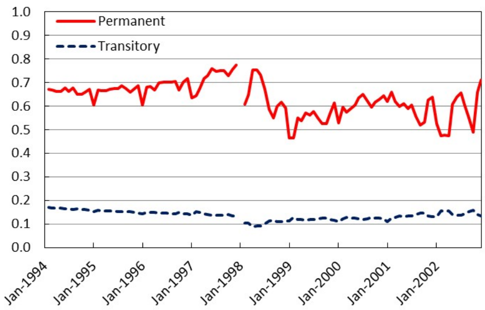
Notes: The house price index comes from Statistics Korea, and wealth variables comes from our sample

Figure 3.3 Nationwide House Price Index and Constructed Average Housing Wealth

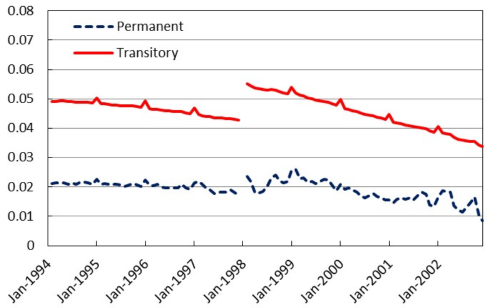


Source: Statistics Korea

Figure 3.4 Estimated Income Shocks and Consumption Insurance



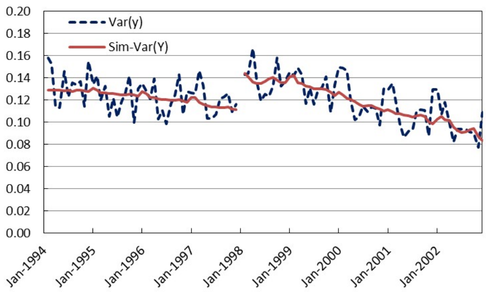
(a) Consumption Insurance: $\overline{\phi_t}$ and $\overline{\psi_t}$



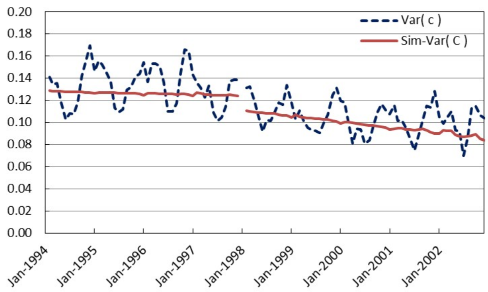
(b) Income Shocks: $\overline{\sigma^2_{\zeta t}}$ and $\overline{\sigma^2_{\varepsilon t}}$

Note: $\overline{x_t} = \frac{1}{N}\Sigma_{i=1}^{N} x_{it}$

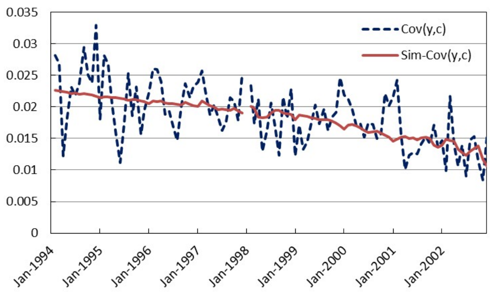
Figure 3.5 Goodness of Fits Under the Baseline Specification



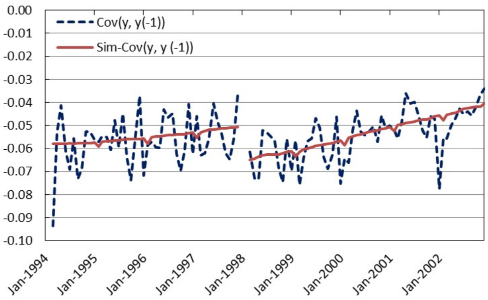
(a) $Var(\Delta y_{it})$



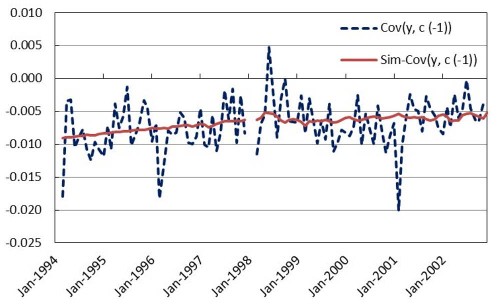
(b) $Var(\Delta c_{it})$



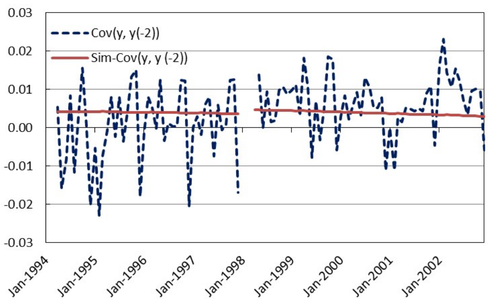
(c) $Cov(\Delta y_{it}, \Delta c_{it})$



(d) $Cov(\Delta y_{it}, \Delta y_{it-1})$



(e) $Cov(\Delta y_{it}, \Delta c_{it-1})$



(f) $Cov(\Delta y_{it}, \Delta y_{it-2})$

Table 3.1 Estimation Results of Nationwide House Price Process: ARIMA(1,1,1)

	Constant	AR(1)	MA(1)	Sigma
Coefficient	0.002	0.725***	0.281**	0.005***
	(0.002)	(0.067)	(0.140)	(0.000)

Note: Standard errors in parenthesis: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 3.2 Sample Selection Results

	# of HH	(HH Diff.)	# of Obs.	(Obs. Diff.)
Raw	10,481		301,692	
Excl. HHs: Experiencing changes in head of HH	8,749	(-1,732)	239,385	(-62,307)
Excl. Obs.: Head's age is below 25 or over 60	8,087	(-662)	215,895	(-23,490)
Trim top and bottom 1p of income obs. by month	8,083	(-4)	211,702	(-4,193)
Excl. Obs.: Monthly Income Growth (below -80% or over 500%)	8,083	(0)	209,888	(-6,007)

Note: Second row in the table implies that a household whose head's age does not increase by up to one year is excluded from the sample ($\Delta Age_{it} < 0$ or $\Delta Age_{it} > 1$)

Table 3.3 Comparison of Total Wealth Composition Between FIES and KHPS

	Housing Wealth	Jeonse Deposit	Savings	Equity	Others
FIES	77.4%	12.6%	8.9%	0.6%	0.5%
KHPS	74.2%	11.0%	10.6%	2.6%	1.6%

Note: The numbers in row 1 come from our sample. Row 2 uses the Korean Household Panel Study conducted by Daewoo Economic Research Institute and show the average share of asset holdings between 1994 and 1997
Source: Lim (2004)

Table 3.4 Regression of Changes in Scaled Net-Wealth on Constructed Wealth Shock

Dependent variable: $\Delta a_{it}/W_{it-1}$	(1)	(2)	(3)	(4)
Z_{it}^{H}	0.925***	0.945***		
	(0.010)	(0.010)		
$D_{it-1}^{H} \times \Delta p_t^H$			0.224***	
			(0.003)	
Δp_t^H			0.071	
			(0.058)	
$Z_{it}^{H} \times I_{\{t\in[Jan.1994,Dec.1997]\}}$				0.880***
				(0.027)
$Z_{it}^{H} \times I_{\{t\in[Jan.1998,Dec.2002]\}}$				0.927***
				(0.011)
a_{it-1}/W_{it-1}	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Fixed-Effect	N	Y	N	N
Number of Observations	192,623	192,623	192,623	192,623
R^2	0.380	0.357	0.302	0.380

Notes: Standard errors in parenthesis are clustered on household: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. R^2 of specification (2) denotes R^2-between. D_{it-1}^{H} has the value one if the individual owns a house in the previous month and has the value zero, otherwise. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies. $I_{\{t\in[\cdot]\}}$ is an indicator function having the value one if a time period is included in the given time period $[\cdot]$ and the value zero, otherwise.

Table 3.5 Regression of Consumption Growth on Wealth Shock

Dependent Variable: ΔC_{it}	(1)	(2)	(3)	(4)
Z_{it}^{H}	1.886***	1.949***	2.453***	
	(0.398)	(0.406)	(0.536)	
Z_{it}^{H-exp}				1.559***
				(0.490)
$Z_{it}^{H-unexp}$				2.646**
				(1.188)
D_{it-1}^{H}	-0.002***		-0.006	-0.002***
	(0.001)		(0.005)	(0.001)
$\boldsymbol{a_{it-1}^{H}}/W_{it-1}$		-0.009***		
		(0.003)		
Fixed-Effect	N	N	Y	N
Num. of Obs.	189,636	189,636	189,636	189,636

Notes: Standard errors in parenthesis are clustered on household: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies.

Table 3.6 Minimum Distance Estimation Results

		(1) Baseline		**(2) Using $Z_{it-1}^{H-cumul}$**		**(3) Without Z_{it-1}^{H-prev}**	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
σ_ζ^2	Constant	0.004**	(0.001)	0.003*	(0.001)	0.003	(0.002)
	Z_{it-1}^{H-prev}	0.002***	(0.001)	0.001***	(0.000)		
	D_{it-1}^{H}	0.024***	(0.002)	0.024***	(0.002)	0.028***	(0.002)
	$I_{\{t\geq Jan.1998\}}$	0.008***	(0.001)	0.010***	(0.001)	0.004	(0.003)
	$\tilde{t}$	- 0.001	(0.003)	- 0.001	(0.003)	- 0.001	(0.001)
	$\tilde{t}\times I_{\{t\geq Jan.1998\}}$	-0.002**	(0.001)	-0.002	(0.001)	- 0.001	(0.001)
σ_ε^2	Constant	0.026***	(0.004)	0.026***	(0.004)	0.027***	(0.004)
	Z_{it-1}^{H-prev}	0.000	(0.000)	- 0.000	(0.000)		
	D_{it-1}^{H}	0.027***	(0.006)	0.029***	(0.006)	0.026***	(0.007)
	$I_{\{t\geq Jan.1998\}}$	0.013***	(0.001)	0.012***	(0.001)	0.013***	(0.002)
	$\tilde{t}$	- 0.002	(0.002)	- 0.002	(0.002)	-0.002***	(0.001)
	$\tilde{t}\times I_{\{t\geq Jan.1998\}}$	-0.002***	(0.001)	-0.002**	(0.001)	-0.002***	(0.001)
ϕ	Constant	1.258***	(0.116)	1.306***	(0.106)	1.314***	(0.084)
	Z_{it-1}^{H-prev}	-0.055***	(0.010)	-0.012***	(0.004)		
	D_{it-1}^{H}	-0.933***	(0.049)	-0.964***	(0.042)	-1.037***	(0.054)
	$I_{\{t\geq Jan.1998\}}$	-0.209*	(0.109)	-0.203*	(0.111)	- 0.085	(0.095)
	$\tilde{t}$	0.030	(0.030)	0.035	(0.025)	0.014	(0.026)
	$\tilde{t}\times I_{\{t\geq Jan.1998\}}$	- 0.002	(0.033)	- 0.016	(0.028)	- 0.013	(0.035)
	Age_{it}	0.001	(0.002)	0.001	(0.001)		
ψ	Constant	0.131***	(0.043)	0.137***	(0.043)	0.191***	(0.027)
	Z_{it-1}^{H-prev}	0.007***	(0.002)	- 0.000	(0.002)		
	D_{it-1}^{H}	-0.103***	(0.014)	-0.107***	(0.015)	-0.089***	(0.023)
	$I_{\{t\geq Jan.1998\}}$	- 0.018	(0.038)	- 0.031	(0.041)	- 0.033	(0.030)
	$\tilde{t}$	- 0.007	(0.018)	- 0.007	(0.020)	- 0.005	(0.008)
	$\tilde{t}\times I_{\{t\geq Jan.1998\}}$	0.010	(0.019)	0.015	(0.021)	0.013	(0.010)
	Age_{it}	0.002**	(0.001)	0.001**	(0.001)		
σ_ξ^2	Constant	0.109***	(0.003)	0.109***	(0.003)	0.109***	(0.003)
	$I_{\{t\geq Jan.1998\}}$	- 0.001	(0.001)	- 0.001	(0.004)	- 0.001	(0.001)
	$\tilde{t}$	-0.013***	(0.004)	-0.012***	(0.001)	-0.013***	(0.004)
	$\tilde{t}\times I_{\{t\geq Jan.1998\}}$	-0.003**	(0.001)	-0.003**	(0.001)	-0.003**	(0.001)
θ (MA(1) Parameter)		-0.086***	(0.011)	-0.085***	(0.011)	-0.085***	(0.014)

Notes: Standard errors in parenthesis. In order to meet the relative size of the coefficients, Z_{it-1}^{H-prev} and $Z_{it-1}^{H-cumul}$ are multiplied by 1,000. $\tilde{t}$ is normalized by $(t-49)/10$ where t has the value 1 and 108 if the period is Jan.1994 and Dec. 2002, respectively

Table 3.7 Average of the Variance of Income Shocks and Consumption Insurance By Before- and After-Crisis Period

	σ_ζ^2			σ_ε^2			ϕ			ψ		
	All	B.C.	A.C.	All	B.C.	A.C.	All	B.C.	A.C.	All	B.C.	A.C.
Baseline	0.019	0.020	0.018	0.046	0.047	0.045	0.633	0.685	0.592	0.136	0.150	0.125
Use $Z_{it-1}^{H-Cumul}$	0.019	0.020	0.018	0.046	0.047	0.045	0.640	0.693	0.597	0.135	0.150	0.124
W/O Z_{it-1}^{H-prev}	0.019	0.021	0.018	0.046	0.047	0.045	0.623	0.664	0.591	0.136	0.151	0.125

Note: The B.C. (before-crisis) period covers the time between January.1994 and December.1997, and A.C. (after-crisis) period covers the time between January.1998 and December.2002

Table 3.8 Decomposition of the Variance of Consumption Growth Unexplained by Demographics

	Before-Crisis		After-Crisis	
	Average	Dec.97 - Feb.94	Average	Dec.02 - Feb.98
$\Delta var(\vartheta)$	- 0.00007	- 0.00329	- 0.00042	- 0.02457
$\gamma^2 \Delta var(Z^{H-unexp})$	0.00000	0.00000	- 0.00000	- 0.00003
$var(\zeta) \times \Delta\phi^2$	0.00005	0.00254	- 0.00003	0.00117
$\Delta var(\zeta) \times \phi^2_{-1}$	- 0.00003	- 0.00176	- 0.00004	- 0.00549
$var(\varepsilon) \times \Delta\psi^2$	- 0.00001	- 0.00048	0.00001	0.00022
$\Delta var(\varepsilon) \times \psi^2_{-1}$	- 0.00000	- 0.00019	- 0.00001	- 0.00024
$\Delta var(\xi)$	- 0.00007	- 0.00341	- 0.00035	- 0.02020

Notes: The average monthly value of each component is calculated by $var(Y_t) = \frac{1}{N_t}\Sigma_i var(Y_{it})$, where Y_{it} is an arbitrary variable. The before- or after-crisis period average level of contribution of consumption growth variance is derived by $\Delta var(\Delta c_j) = \frac{1}{T_j}\Sigma_{t \in j}\Delta var(\Delta c_t)$ where $j \in \{Before - Crisis, After - Crisis\}$. The Before-Crisis period covers the time between January.1994 and December.1997, and After-Crisis period covers the time between January.1998 and December.2002. Dec.97 - Feb.94 implies that the monthly average values in December.1997 is subtracted by that of February.1994

Appendix A

Appendix for Chapter 1

A.1 Institutional Background

Korea provides a particularly suitable environment to study interaction between intrafamily resource sharing and elderly people's labour supply choice. The country is facing unprecedented demographic changes. It became an ageing society in 2000, and has been becoming an super-aged society rapidly. As the country undergoes a rapid ageing process, OECD predicts that Korea becomes the oldest society among OECD countries in the 2050s (**?**). Amid ageing process, a much higher proportion of elderly Korean people aged 55 or more participates in the labour force than that of the OECD average, while the poverty rates of people aged 65 or order is the highest among other member countries in OECD. Weak social insurance programs also cause people to rely more on their earned income. As a result, older people's labour supply is less likely to be affected by the changes in social security rules, and there is more room for IVFT to play an important role in elderly workers' lifetime choice.[1]

A.1.1 Employment Rate

The LFP rate for elderly men in Korea has continued to be high during the period under this study. The LFP rate for those aged 65 or more has continued to exceed 40%. Comparing it with the OECD average, a much higher proportion of elderly Korean participates in the labour force, and these higher LFP rates translate into around 9%p and 23%p for men aged 55-64 and 65 or more, respectively.

Various increasing demands from family members, especially children, are pointed out as important factors which mainly force elderly people to delay retirement. The

[1] 58% of workers aged 55-79 report that their primary reason for work is to earn or supplement their living costs, and just 35% point enjoying their work out as a major reason (**?**)

rise in educational investment for next generation and the mounting competition in the young workers' job market increase the need for elderly people to provide more resources and support with their children (**?**). For example, the unemployment rate of young working-age adults (20-29) has increased by 1.8%p for men and 2.3%p for women between 2006-2016, respectively. A high level of unemployment among young people leads to an extension of job search period, and thus, the initial employment age, which was 27.3 years old in 2008, increased significantly to 31.2 years old in 2016.[2]

A.1.2 Public Pension System

Comparing it with other OECD countries, public pension plans in Korea are relatively recent phenomenon. The government established two kinds of social security system.[3] One is the National Pension Scheme (NPS) designed as a contributory social security program established in 1988. The NPS was originally designed for an income replacement rate (IRR) of 70% of average monthly income if an individual contributes over a 40-year of pension covered employment period and allowed to draw from the age of 60. After the age of 60, individuals do not need to pay contributions and the amount of benefits does not accrue. To be eligible for NPS, an individual needs to be insured at least 10 years. In 2008, IRR was lowered to 50% and will be gradually decreased by 0.5%p every year until 2028 (IRR will become 40%). Also, from 2013, pension age has increased by one year (age 61) and will be raised by one year every five years until 2033 (full pension age will become 65). Due to pre-matured NPS, as of October 2018 just 38.8% of people aged 65 or over has received NPS (old-age pension), and average monthly pension amount as of December 2018 is just 501,619KRW (around U.S. $424) which is below 30% of the minimum living cost for a two-person household.[4]

The other is Basic Old-Age Pension Scheme (BOAPS) designed as a public assistance program established in 2008. BOAPS is tax-financed program which is introduced for the people who have not contributed the NPS more than 10 years and aimed at elderly people who are experiencing economic hardship. The BOAPS is given for elderly people who meet the age and income-assets conditions.[5] Thus,

[2]source: incruit.com

[3]It also has a separate occupational pension system; Government Employees Pension, Military Servicemen Pension and Private School Teachers Pension

[4]34.8% and 4.0% of people aged 65 or over receive NPS and occupational pension, respectively. Also, the average qualifying years of NPS contribution is 12.1 years in 2018.

[5]When BOAPS was first introduced, eligible age was at least 70. Since August 2008, the age limit for BOAPS has been lowered to 65. In terms of incomes and assets, lower 60% of the elderly people are eligible, and the eligibility standard has eased to lower 70% since January 2009

it can be regarded as a means-tested elderly welfare programmes rather than a sort of pension. As of June 2014, 65.1% of elderly people aged 65 or older received BOAPS, and the maximum monthly amount of support for two-person household is 158,600KRW (around U.S. $135) which is lower than any other OECD country. BOAPS has been replaced by Basic Pension Scheme (BPS) since July 2014, and the size of maximum monthly benefit also has risen to 480,000KRW for two-person household. Even after introducing the new program, however the amount of benefit is still the lowest among OECD countries.

A.2 The Formal Proof of the Proposition 1

With the assumption of imperfect altruism ($0 < \eta_k, \kappa_k < 1$), at most one party provides financial transfers. Because the model assumes that an IVFT provider leads the game, a fatal contradiction may occur when there exists equilibrium allocation which both parties provide financial transfers in the same time. Thus, the validity of this statement can be suggested using a proof by contradiction. I assume that it is possible for parents and child to provide IVFT for the other party in the same period game t (*i.e.* assume $TR_t^p > 0$ & $TR_t^c > 0$ hold at time t). In order for simultaneous two-way transfers to occur in the same family, the equation (1.41) and (1.46) need to hold at the same time:

$$\begin{aligned} \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} = \eta_k \frac{\partial \widetilde{u}_t^c}{\partial c_t^c} \ \wedge \ \frac{\partial \widetilde{u}_t^c}{\partial c_t^c} &= \kappa_k \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} + \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}} \quad \longrightarrow \\ \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} &= \eta_k \kappa_k \frac{\partial \widetilde{u}_t^p}{\partial c_t^p} + \eta_k \beta(1 - p_{t+1}^{hs_{t+1} \neq 3}) E_t \frac{\partial B(A_{t+1})}{\partial A_{t+1}} \end{aligned} \tag{A.1}$$

If η_k, κ_k, and survival rate are sufficiently high, it can be an optimal for each party in the family to provide and receive transfers at the same time. However, in this model, altruism toward the other family member in different household is imperfect, and death rate is not sufficiently low. Also, estimated bequest curvature K is relatively high. Thus, the equation (A.1) does not hold in general.[6] Therefore, it must be the case that at most one party can provide IVFT during a given period game t.

[6]Put somewhat differently, except in very exceptional cases, the equation (A.1) is contradiction because of imperfect altruism.

A.3 Health Transition Probabilities, Out-of-Pocket Medical Costs, and Non-Labour Income

The ordered logistic estimates of health transition probabilities are given in table A.1. The transition rates from better to poor health condition increase with age. Also, given the age and previous period health status, the health condition of elderly in the high educational attainment group is less likely to be deteriorated. The estimates for medical expenditure are summarized in table A.2. As expected, there is positive correlation between age and the amount of medical costs. The coefficient on the level of net assets shows that a wealthier individual is more likely to choose better quality of care (or go to the hospital more often). In addition, given the age, asset levels and household type, the elderly with 'Good' health pay 29.2% and 43.3% less out-of-pocket health costs than an individual with 'Fair' and 'Bad' state on average, respectively.

The average marginal effects (AME) for wife's LFP of first stage binomial probit regression are given in table A.3. These estimates of the selection process are used to generate inverse Mills ratio for each female household member. Panel 1 of table A.3 shows the AME of elderly wife's participation. First, individuals face strong retirement incentives with age. For every three years, the probability of participation in the labour force decreases by 6.1%p. Second, although the sign of coefficient on net-assets is positive, it is statistically insignificant at the 5% level, and its effect on wife's participation choice is negligible. Third, her husband's schooling is negatively associated with her labour supply. Lastly, a wife is more likely to work when her husband health is more deteriorated. Panel 2 shows the AME of young wife's LFP. Her estimated participation probabilities increase until mid 40s and then decreases. Also, the wife of child-household is more likely to participate in the labour force if her husband's education level is categorized as high-group. The estimation results for the second stage of wife's yearly earnings are presented in table A.4. The coefficients on inverse Mills ratio of parents (child) household indicate positive (negative) selection, however the null hypothesis of no-selection is not rejected in any case.

Table A.1 Estimates of Health Transition: Ordered Logistic Regression

hs_{it}	Coeff.	(S.E.)
age^p_{it}	0.487**	(0.208)
$(age^p_{it})^2/10^2$	-0.603**	(0.307)
$(age^p_{it})^3/10^4$	0.281*	(0.150)
Dummy: $Edu^p_i = H$	-0.397***	(0.034)
hs_{it-1}	1.529***	(0.022)
Cut Points between Good-Fair	Fair-Bad	Bad-Dead
15.394	16.827	21.158
Pseudo R^2		0.227

Notes: Standard errors are provided in parenthesis: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. $Age^p_{it} = 1$ if male-parent's age is between 55 and 57. Afterwards Age^p_{it} is increased by one-unit in every three years

Table A.2 Estimates of Medical Expenses

Dependent: $ln\ oop_{it}$	Coeff.	(S.E.)
age^p_{it}	0.120***	(0.026)
$(age^p_{it})^2/10^2$	-0.006**	(0.003)
Log Net Assets	0.042***	(0.012)
Dummy: $Edu^p_i = H$	-0.025	(0.033)
$hs_{it} = Fair$	0.292***	(0.043)
$hs_{it} = Bad$	0.433***	(0.057)
Constant	0.787***	(0.117)
σ^2_u		0.647
Adjusted R^2		0.082
RMSE		0.805

Note: Robust standard errors are provided in parenthesis: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table A.3 Estimates of Wife's labour Force Participation Model: 1st Stage Probit Regression

	Parents-HH			Child-HH	
	Coeff.	(S.E.)		Coeff.	(S.E.)
Log Net Asset	0.010**	(0.005)	$age_{it}^{c,w}$	-0.036*	(0.019)
$age_{it}^{p,w}$	-0.061***	(0.005)	$(age_{it}^{c,w})^2/100$	0.001**	(0.000)
Dummy: $Edu_i^p = H$	-0.053***	(0.016)	Dummy: $Edu_i^c = H$	0.051**	(0.022)
$hs_{it} = Fair$	0.030	(0.021)			
$hs_{it} = Bad$	0.139***	(0.027)			

Notes: Robust standard errors are provided in parenthesis: *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.10. Figures in the column 2 and 5 show the average marginal effects. Female-parents whose age is between 54-74 are used to estimate the participation equation. $age_{it}^{p,w} = 1$ if female-parent's age is between 54-56. Afterwards $age_{it}^{p,w}$ is increased by one-unit in every three years. Female-child aged 25-64 are used to estimate the participation equation

Table A.4 Estimates of Wife's Yearly Earnings Equation: Second Stage

	Parents-HH			Child-HH	
	Coeff.	(S.E.)		Coeff.	(S.E.)
Inverse Mills Ratio	0.870	(0.684)	Inverse Mills Ratio	- 0.034	(5.552)
$age_{it}^{p,w}$	- 0.096	(0.071)	$age_{it}^{c,w}$	0.068	(0.057)
$(age_{it}^{p,w})^2/100$	0.003	(0.009)	$(age_{it}^{c,w})^2/100$	- 0.001	(0.001)
Dummy: $Edu_i^p = H$	0.276***	(0.065)	Dummy: $Edu_i^c = H$	0.296*	(0.162)
Constant	6.878***	(0.337)	Constant	6.156**	(2.816)
R^2		0.08			0.05
RMSE		0.706			0.684

Notes: Robust standard errors are provided in parenthesis: *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.10. Female-parents whose age is between 54-74 are used to estimate the earnings equation. $age_{it}^{p,w} = 1$ if female-parent's age is between 54-56. Afterwards $age_{it}^{p,w}$ is increased by one-unit in every three years. Female-children aged 25-64 are used to estimate the earnings equation. Estimated coefficients for time-dummies (2007-2016) are not presented in the table

Appendix B

Appendix for Chapter 2

B.1 Wage, Medical Expenses, and Spousal Income

It is assumed that the deterministic productivity component of logarithm wage in paid-job ($ln\ w_{it}^{PJ}$) and self-employment ($ln\ w_{it}^{SE}$) is a linear function of individual fixed effect, age, sector specific work experience and health:

$$\begin{aligned}
ln\ w_{it}^{PJ} =& (f_i + \beta_0^{PJ} age_{it} + \beta_1^{PJ} age_{it}^2 + \beta_2^{PJ} x_{it}^{PJ} + \beta_3^{PJ} \times 1_{\{hs_{it}=Fair\}} + \beta_4^{PJ} \times 1_{\{hs_{it}=Bad\}}) \\
& \times (1 - \varsigma \times 1_{\{h_{it} \leq 1{,}500\}}) + v_{it}, \quad v_{it} = \rho_{AR} v_{it-1} + \xi_{it} \qquad \text{(B.1)} \\
& f_i \sim N(\mu_f, \sigma_f^2), \quad \xi_{it} \sim N(0, \sigma_\xi^2) \\
ln\ w_{it}^{SE} =& \varphi_i + \beta_0^{SE} age_{it} + \beta_1^{SE} age_{it}^2 + \beta_2^{SE} x_{it}^{SE} + \beta_3^{SE} \times 1_{\{hs_{it}=Fair\}} \\
& + \beta_4^{SE} \times 1_{\{hs_{it}=Bad\}} + \psi_{it} \qquad \text{(B.2)} \\
& \varphi_i \sim N(\mu_\varphi, \sigma_\varphi^2), \quad \psi_{it} \sim N(0, \sigma_\psi^2), \quad Corr(\varphi_i, f_i) = \rho
\end{aligned}$$

The functional forms of medical expenses (m_{it}) and expected amount of married women's income ($E_t(si_{it})$) are expressed as equation (B.3) and (B.4):

$$\begin{aligned}
ln\ m_{it} =& \beta_0^M + \beta_1^M age_{it} + \beta_2^M age_{it}^2 + \beta_3^M age_{it}^3 + \beta_4^M ln\ a_{it} + \beta_5^M 1_{\{Medicare_{it}\}} \qquad \text{(B.3)} \\
& + \beta_6^M 1_{\{hs_{it}=Fair\}} + \beta_7^M 1_{\{hs_{it}=Bad\}} + u_{it}, \quad u_{it} \sim N(0, \sigma_u^2) \\
E_t(si_{it}) =& E(si_{it} | age_{it}^s, hs_{it}, f_i) = p_{it}^s\,(age_{it}^s, hs_{it}, E_t(ln\ m_{it})) \times w_{it}^{si}(age_{it}^s, f_i) \qquad \text{(B.4)} \\
p_{it}^s =& P\{LFP_{it}^s = 1 | \cdot\} = \Phi\left(\beta_0^p + \beta_1^p age_{it}^s + \beta_2^p (age_{it}^s)^2 + \beta_3^p hs_{it} + \beta_4^p E_t(ln\ m_{it})\right) \\
ln\ w_{it}^{si} =& \beta_0^{si} + \beta_1^{si} age_{it}^s + \beta_2^{si} (age_{it}^s)^2 + \beta_3^{si} f_i
\end{aligned}$$

where LFP_{it}^s takes the value 1 if a married woman participates in the labour force and has the value 0, otherwise.

B.2 Social Security Retired Worker Benefit

Once a worker has claimed Social Security Retired Worker Benefit (SSB, ssb_{it}), he will receive the benefit for life. The amount of ssb_{it} depends on many factors such as a worker's lifetime earnings, the choice of time for first claiming benefit and employment decisions. The SSB has a negative effect on work incentives after a certain age. In order to properly capture work and retirement incentives caused by the U.S. Social Security retirement program, model trying to explain individual's work and retirement decision should reflect the following stylized facts adequately: (1) Eligibility, (2) Average Indexed Monthly Earnings (AIME) and Primary Insurance Amount (PIA) and (3) Full, Early and Delayed Retirement Age.

Eligibility: To be eligible for SSB, an individual needs at least 10 years of Social Security covered employment. The earliest age when an agent can claim SSB known as Early Eligibility Age (EEA) is the age of 62. In 2012, 47% of individuals has claimed the benefit from the age of 62, and 63% of beneficiaries were under the age of 65. This study assumes that every individual claims the benefit no later than age 70 because only around 2% of beneficiaries claimed benefit at the age of 70 or over. Moreover, due to the fact that only 5.6% of individuals in the sample have less than 10 years of work history, and around 65% of individuals have worked more than 35 years at the age of 62, it is assumed that every individual is eligible for SSB and has already worked 35 years or more.

Average Indexed Monthly Earnings (AIME) and Primary Insurance Amount (PIA): SSB are based on individual's 35 highest earnings taken over up to 35 years. The average earnings over these 35 highest earnings years are called AIME. Thus, if an individual has worked less than 35 years, an additional year of work directly increases his AIME. If he already has worked 35 years or more, AIME will be adjusted only if his earnings from an additional year of work are higher than the lowest earnings included in his current AIME. Because this study assumes that every male-individual has already worked more than 35 years, his AIME is only adjusted if his current earnings are higher than the lowest earnings in AIME. Also, in order to reflect real wage growth in the economy, AIME are adjusted by the growth rate of national wage index. However, this adjustment stops at the year when workers become age 60 (*i.e.* After age 60, AIME is not adjusted automatically). PIA is the basis in the calculation of SSB and is linked to the AIME by a piecewise linear function:

$$PIA_t = \begin{bmatrix} 0.9 \times AIME_t & if\ \ AIME_t < C_1 \\ 0.9 \times C_1 + 0.32 \times (AIME_t - C_1) & if\ \ C_1 \leq AIME_t < C_2 \\ 0.9 \times C_1 + 0.32 \times (C_2 - C_1) + 0.15 \times (AIME_t - C_2) & if\ \ C_2 \leq AIME_t \end{bmatrix} \quad \text{(B.5)}$$

where the 2000 bend points are used in this paper are C_1 = \$531 and C_2 = \$3,202.

Full, Early and Delayed Retirement Age: SSB depends not only on PIA but also on age at which the individual first draws it. The age at which unreduced retirement benefits are first available is called the Full Retirement Age (FRA) or Normal Retirement Age (NRA). Following Social Security Amendments of 1983 (P.L.98-21), the FRA has gradually been increased from age 65 in 2002 (people born in 1937) to 67 in 2027 (born in 1960). In this paper, I regard age 66 as the FRA. The total amount of benefits received by individuals satisfying FRA is given using the equation (B.6).

$$ssb_t = \begin{bmatrix} 1.5 \times PIA_t & if\ PIA_t < D_1 \\ 1.5 \times D_1 + 2.72 \times (PIA_t - D_1) & if\ D_1 \leq AIME_t < D_2 \\ 1.5 \times D_1 + 2.72 \times (D_2 - D_1) + 1.34 \times (PIA_t - D_2) & if\ D_2 \leq PIA_t < D_3 \\ 1.5 \times D_1 + 2.72 \times (D_2 - D_1) + 1.34 \times (D_3 - D_2) + 1.75 \times (PIA_t - D_3) & if\ D_3 \leq PIA_t \end{bmatrix} \text{(B.6)}$$

where the bend points correspond to 2000 are D_1 = \$679, D_2 = \$980 and D_3 = \$1,278.

Although people can claim SSB from the age 62 (if he satisfies the condition of at least 10 years of Social Security covered employment history), benefit will be permanently reduced if they draw before the FRA, and it will be greater than their PIA if they delay drawing it after the FRA. For every year before the FRA, retirement benefits are reduced by 6.7% up to 3 years, and in excess of 3 years, the benefits are reduced by 5% a year. Workers who start drawing benefit after the FRA receive a Delayed Retirement Credit (DRC). The DRC applies starting with the month the workers attain the FRA and ending with the month before they become the age 70. Since 1990, the DRC has increased from 5.5% (born between 1933-1934) per year and will increase 0.5%p in every two-year until it reaches 8.0% (born in 1943 or later) per year.[1]

[1] In this paper, if an individual draw the benefit before the age 66, it is reduced by 6.7% ($AIME \times 0.933^n$) for every year, and if SSB application is delayed, he will get a benefit increase by 7.0% ($AIME \times 1.07^n$) every year.

B.3 Tax Structure

The tax system in the U.S. is composed of payroll tax, federal tax and taxes on social security benefits (SSB). The tax rates and exemption amounts used below are the figures in 2000.

Payroll Tax: Payroll taxes are collected under the Federal Insurance Contribution Act (FICA) and Self- Employment Contribution Act (SECA), which are used to finance the Old-Age Survivors, and Disability Insurance (OSADI) program and Medicare Hospital Insurance (Medicare HI). These taxes are levied on the wages and net self-employment income. If an individual works for an employer, the tax is shared by the employee and employer, and each pays half of the total amount. Thus, effective social security tax rate for employees is 6.2% of earnings up to an upper limit of \$76,200, and the Medicare tax rate is 1.45% of earnings (there is no upper limit). The SECA tax is levied at a rate of 15.3% for self-employed, with the same 12.4% and 2.9% split between OASDI and Medicare HI similar to the FICA tax. The only difference is that self-employed have to bear these taxes on their own. However, unlike paid-workers, self-employed are allowed to deduct one-half of the SECA taxes for federal income tax purposes. Each workers' payroll tax contribution ($\tau^P w_{it} h_{it}$) can be expressed by:

$$\begin{aligned} \tau^P w_{it} h_{it} = & \Big[0.062(1 + 1_{\{k_{it}^j=2\}})\Big] \times min\{76,200, w_{it}h_{it}\} \\ & + \Big[0.0145(1 + 1_{\{k_{it}^j=2\}})\Big] \times w_{it}h_{it} \end{aligned} \tag{B.7}$$

where τ^P is payroll tax rate, and $1_{\{k_{it}^j=2\}}$ denotes an indicator variable, which has value 1 if the agent is self-employed and has the value 0 if otherwise.

Taxable Social Security Benefits: Since 1984, SSB have been subject to the federal income tax. Up to 50% of SSB are taxable for single taxpayers whose provisional income (PI) exceeds \$25,000 (first-tier threshold for single taxpayer).[2,3] Thus, if an individual's PI is below 1st-tier threshold, the full amount of SSB is not taxable. Since 1993, new law (Omnibus Budget Reconciliation Act) has been in effect, and it taxes up to 85% of SSB for single taxpayers whose PI exceeds \$34,000 (second-tier threshold). Therefore, if an individual's PI is greater than 2nd-tier

[2] In this study, it is assumed that individuals choose the option of married filing separately.

[3] PI is adjusted gross income. I use individual's earned income and 50% of SSB as PI.

threshold, the amount of SSB subject to tax is smaller or equal to $4,500 plus 85% of PI above the 2nd-tier threshold.[4]

$$(1-\tau^{SSB})ssb_t = \begin{bmatrix} ssb_t & if\ \ PI < \$25,000 \\ max(ssb_t - \frac{1}{2} \times (PI - \$25,000), 0) & if\ \ \$25,000 \leq PI < \$34,000 \\ max(ssb_t - \$4,500 - 0.85 \times (PI - \$34,000), 0) & if\ \ \$34,000 \leq PI \end{bmatrix} \quad \text{(B.8)}$$

Federal Income Tax: The income tax is levied on labour and non-labour income. I use the Federal Income Tax tables for "Single Tax Bracket". The standard deduction for a single was $4,400. The tax bracket and marginal tax rate are summarized in below table. Post-tax income structure is denoted as:

$$\begin{aligned} & Y(ra_{it}, w_{it}h_{it}, \tau^F, \tau^P, \tau^{SSB}) \\ & \qquad = (1-\tau^F)\left[(1-\tau^P)w^h_{it}h^h_{it} + ra_{it} + (1-\tau^{SSB})ssb_t B_{it-1}\right] \end{aligned} \quad \text{(B.9)}$$

where τ^F is the vector of the federal tax structure. B_{it} has the value one if the agent applied SSB and has the value zero, otherwise.

Pre-Tax Income ($)	Post-Tax Income ($)	Marginal Tax Rate (%)
0 - 4,440	Y	0.0
4,440 - 30,650	4,400 + 0.850×(Y - 4,400)	15.0
30,650 - 67,950	26,712.5 + 0.720×(Y - 30,650)	28.0
67,950 - 137,000	53,568.5 + 0.690×(Y-67,950)	31.0
137,000 - 295,700	101,213 + 0.640×(Y-137,800)	36.0
292,750 and over	200,893 + 0.604×(Y-292,750)	39.6

Note: Pre-Tax Income=After payroll tax earned income+interest income from assets

[4] In order to generate the SSB taxation structure properly, I use IRS Publication 915 and set $\tau^{SSB}(ssb_t)$ as equation (B.8).

Appendix C

Appendix for Chapter 3

C.1 Measuring Lifetime Wealth

The lifetime wealth $W_{it}(m)$ of household i at age m which is evaluated at time t is consisted of current wealth a_{it} and the present value of expected future income $PVFI_{im}$.[1]

$$W_{it}(m) = a_{it} + PVFI_{im} \tag{C.1}$$

In order to derive each household's present value of lifetime-income when an individual i is m-years old, it is assumed that all household heads are expected to retire and die at the age of 60 and 80, respectively. With regard to measuring labor income before the age of 60, we first estimate the monthly log household income Y_{it} for a household i in period t with following simple specification:

$$\begin{aligned} Y_{it} =& \beta_0 + Age_{it}\ \beta_1 + Age_{it}^2\ \beta_2 + I_{\{HS_i=1\}}\ \beta_3 + Age_{it} \times I_{\{HS_i=1\}}\ \beta_4 + I_{\{Col_i=1\}}\ \beta_5 + \\ & Age_{it} \times I_{\{Col_i=1\}}\ \beta_6 + HHsize_{it}\ \beta_7 + Child_{it}\ \beta_8 + \tau_t + y_{it} \end{aligned} \tag{C.2}$$

where Age_{it} denotes the household head's age. $I_{\{\cdot\}}$ is an indicator function, which has the value one if an individual's current state corresponds to $\{\cdot\}$ and the value zero, otherwise. HS_i (Col_i) has the value one if the head received high-school (college) or higher degree and has the value zero, otherwise. $HHsize_{it}$ and $Child_{it}$ denote the number of household members and children under the age of 18, respectively. τ_t is year-month dummies, and y_{it} is the idiosyncratic component of income.

[1] For example, if an individual i is 26 years old in February 1995, then $W_{it}(m)$ is denoted as $W_{i\ Feb.1995}(26) = a_{i\ Feb.1995} + PVFI_{i\ 26}$.

Using the estimated coefficients of equation (C.2), we calculate the predicted mean of the household's earned income P_{im} at all future working age.[2] Also, for the sake of simplicity, income during retirement periods is assumed a constant fraction η of the predicted income in the last period of work life.[3]. Considering the pre-matured national pension system in Korea and following **?**, η is set to 0.24. This implies that all elderly people are eligible for claiming pension which provides the same amount until death and begins to draw the pension at the age of 61. Taken together, a household i's PVFI at the age of m can be expressed by equation (C.3):

$$PVFI_{im} = \sum_{\tau=0}^{80-m} \frac{P_{im+\tau}}{(1+\overline{r})^{\tau}}, \begin{bmatrix} If\ 25 \leq Age_i = m+\tau \leq 60,\ P_{im+\tau} = \hat{P}_{m+\tau} \times exp(\overline{y}_i) \times 12 \\ If\ 60 < Age_i = m+\tau \leq 80,\ P_{im+\tau} = 0.24 \times P_{i60} \end{bmatrix} \tag{C.3}$$

C.2 Estimation Results of Alternative Specifications

C.2.1 Unscaled Wealth Shock

We investigate whether the effect of wealth shocks on consumption are still valid when we do not scale housing market driven shocks by lifetime wealth (hereafter, we express the unscaled wealth shock as $\Delta p_t^H \boldsymbol{a}_{it-1}^H$). This main empirical specification is expressed by equation (C.4). The major interest is examining whether changes in consumption is related to housing market-induced wealth shock, and how different are the effects of unpredictable and predictable housing market shocks

[2]To be specific, P_{im} is derived using the following steps: 1. By age, the size of the household and the number of children under age 18 are assumed to be fixed at the mean across households, and the first period in our data set (Jan.1994) is used as the basis time period for the prediction (*i.e.* $\tau_t = 0$ for all age). Using these variables, fitted log monthly earnings $log\hat{Y}_m$ between age 25-60 are calculated using the estimated coefficients of equation (C.2) at all future working age, 2. Exponential transformation is used to convert $log\hat{Y}_m$ back to monetary values, and then 12 is multiplied on it to get yearly fitted earnings ($\hat{P}_m = exp(log\hat{Y}_m) \times 12$), 3. In order to capture the heterogeneity across households, household-specific average permanent income shock $\overline{y}_i$ is constructed by calculating the average stochastic component of household income ($\overline{y}_i = \frac{1}{N_i}\Sigma_{j=1}^{N_i} y_{ij}$, where N_i is the household i's number of observations), and 4. P_{im} is constructed by multiplying the exponential transformation of $\overline{y}_i$ on yearly fitted earnings (*i.e.* $P_{im} = \hat{P}_m \times exp(\overline{y}_i)$).

[3]It is assumed that all the household heads in the sample leave the labor force from the end of age 60 and receive the time-invariant amount of National Pension benefits between the age of 61-80.

on consumption.

$$\begin{aligned}\Delta C_{it} &= \alpha + \gamma Z_{it}^{H} \times W_{it-1} + \lambda D_{it-1}^{H} + \delta \boldsymbol{X_{it}} + \Delta c_{it} \\ &= \alpha + \gamma \Delta p_t^H \boldsymbol{a}_{it-1}^{H} + \lambda D_{it-1}^{H} + \delta \boldsymbol{X_{it}} + \Delta c_{it} \qquad \text{(C.4)}\end{aligned}$$

where $\boldsymbol{X_{it}}$ includes age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies.

Column 1-4 of table C.1 summarize the estimation results. The first column regresses consumption growth on the unscaled housing market shocks via OLS. Regression in column 2 controls lagged amount of total housing wealth $\boldsymbol{a}_{it-1}^{H}$ in stead of D_{it-1}^{H}. In order to reflect heterogeneity across households, column 3 shows the estimated parameters of the model controlling D_{it-1}^{H} by the fixed-effect method. In column 4, the unscaled wealth shock is divided into predicted and unpredicted shocks, and these effects are estimated by OLS.

As shown in column 1, the estimated coefficient on $\Delta p_t^H \boldsymbol{a}_{it-1}^{H}$ has a positive sign and is highly significant. The estimated effect on consumption growth is 0.0026. Thus, one-unit of unscaled wealth shock ($\Delta p_t^H \boldsymbol{a}_{it-1}^{H} = 1$) leads to a 0.26% change in the consumption growth rate. Moreover, considering the fact that the mean of housing wealth during the sample period under this study was \$69,898 (76.9 million KRW), a 1% increase in the nationwide house price index (*i.e.* the magnitude of unscaled wealth shock is around \$699) leads to a rise in monthly consumption by \$1.82. Column 2 shows that the estimated γ is 0.0027 which does not change much as we replace D_{it-1}^{H} with $\boldsymbol{a}_{it-1}^{H}$. The magnitude of the estimated coefficient on the unscaled wealth effect is 0.0038 which is around 48% greater than that under the specification (1). Column 4 indicates that the estimated coefficient on the expected price shock is 0.027 which is significant at 5% level and comparable with those under the specification (1) and (2). However, the effect of surprise changes in house price on consumption growth is statistically insignificant, and the consumption growth responds less sensitive to the surprise house price shock than predicted one.

C.2.2 Additional Control for the Stock Market Wealth Shock

Under the main specification, we only control the capital gains from the housing market through the constructed wealth shock and estimate the wealth effect. However, the household wealth in this study is constructed under the assumption that both homeowners and equity holders expect capital gains from owning the assets. Thus, the wealth shock induced from the stock market is defined as the constructed stock-holder shock Z_{it}^{E} and derived by the interaction of the lagged fraction of lifetime wealth held in stocks a_{it}^{E}/W_{it-1} with the stock market index (KOSPI) growth rate Δp_t^E. Under this specification, we use both wealth shocks driven by the housing and the stock markets and compare the estimated results with those in table 3.5 in terms of the wealth effect.

Comparing it with table 3.5, the estimation results in table C.2 remain largely unchanged. Regardless of the specifications, the coefficient on Z_{it}^{H} does not change much. Also, the coefficient on Z_{it}^{E} is relatively small and statistically insignificant. These results support that the original wealth shock effects are robust.

C.2.3 Event Study Regression

This subsection answers the question about whether the leads and lags of constructed wealth shock have an effect on consumption growth. If the wealth shocks are unanticipated, household consumption should not respond to future wealth shocks. However, it would be possible that the past shock can have an effect on the consumption schedule through diverse channels. In order to analyse the effect of past or future shocks on current consumption growth, we use the model specification expressed in column 1 (OLS estimation and controlling the lagged house ownership dummy D_{it-1}^{H}) of table 3.5 as the reference specification and include different leads and lags of the constructed wealth shock.

Table C.3 provides the regression results of controlling different leads and lags of the constructed wealth shock. Column 1 and 2 control up to 3rd lags and 1st lag of the constructed wealth shock. Column 3 does not control any lags or lead of Z_{it}^{H}. Column 4 and 5 control up to 1st lead and 3rd leads of the instrument. Regardless of controlling past or future wealth shock, there is a highly significant positive effect of the contemporaneous constructed wealth shock on consumption growth. However, any of the coefficients on lags or leads are not significant except for the coefficient on the 3rd lag in column 1. Also, all five specifications show that the wealth changes driven by the housing market have a permanent effect on the level of consumption.[4]

[4] *i.e.* The aggregation of lead, lag and contemporaneous coefficients is always greater than zero.

C.2.4 Quarterly and Semi-Yearly Data Sets

Another robustness check is to demonstrate the importance of using high-frequency data for estimating the causal effect of the constructed wealth shock on consumption growth properly. One of the important advantages of our data set is that it has long monthly panels and provides detailed high-frequency information. If households' consumption decisions are made at higher-frequency, data at a quarter or annual frequency are likely to suffer from aggregation bias.

Table C.4 and C.5 adopt the same model specifications used in table 3.5, however we employ data aggregation interval of quarter and semi-annual to estimate causal effects, respectively. Table C.4 shows that the signs of the coefficients on Z_{it}^{H} are all positive and correspond to the results in table 3.5, even if the aggregated quarterly observations are used to estimate coefficients. The same patterns are preserved, even if we choose semi-year as a data aggregation interval. However, the coefficients in table C.4 and C.5 are less significant than those in table 3.5, and most of the coefficients are not significant as the data aggregation interval gets longer. These results demonstrate that the data aggregation interval is important, and long data aggregate interval would result in the loss of significance of the results obtained and cause severe aggregation bias.

Table C.1 Regression of Consumption Growth on Unscaled Wealth Shock

Dependent variable: ΔC_{it}	(1)	(2)	(3)	(4)
$Z_{it}^{H} \times W_{it-1}$	0.003**	0.003***	0.004***	
	(0.001)	(0.001)	(0.001)	
$Z_{it}^{H-exp} \times W_{it-1}$				0.003**
				(0.001)
$Z_{it}^{H-unexp} \times W_{it-1}$				0.002
				(0.003)
D_{it-1}^{H}	-0.002***		-0.007	-0.002***
	(0.001)		(0.006)	(0.001)
$\boldsymbol{a_{it-1}^{H}}$		-0.000**		
		(0.000)		
Fixed-Effect	N	N	Y	N
Num. of Obs.	189,616	189,616	189,616	189,616

Notes: Standard errors in parenthesis are clustered on household: *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.10. Top and bottom 0.5 percent of Δa_{it} are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies. $\boldsymbol{a_{it}^{H}}$ is expressed in million KRW

Table C.2 Regression of Consumption Growth on Constructed and Stock Market Wealth Shock

Dependent Variable: ΔC_{it}	(1)	(2)	(3)	(4)
Z_{it}^{H}	1.886***	1.949***	2.452***	
	(0.398)	(0.406)	(0.536)	
Z_{it}^{E}	0.122	0.129	0.639	0.122
	(1.326)	(1.326)	(1.2071)	(1.326)
Z_{it}^{H-exp}				1.559***
				(0.490)
$Z_{it}^{H-unexp}$				2.646**
				(1.188)
D_{it-1}^{H}	-0.002***		-0.006	-0.002***
	(0.001)		(0.005)	(0.001)
$\boldsymbol{a_{it-1}^{H}}/W_{it-1}$		-0.009***		
		(0.003)		
Fixed-Effect	N	N	Y	N
Num. of Observation	189,636	189,636	189,636	189,636

Notes: Standard errors in parenthesis are clustered on household: *** p < 0.01, ** p < 0.05, * p < 0.10. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies.

Table C.3 Event Study Regression: Leads and Lags

Dependent variable: ΔC_{it}	(1)	(2)	(3)	(4)	(5)
Z_{it-3}^{H}	-3.119**				
	(1.223)				
Z_{it-2}^{H}	3.150				
	(2.126)				
Z_{it-1}^{H}	-2.246	-1.754			
	(2.249)	(1.066)			
Z_{it}	2.664**	2.976**	1.886***	2.639***	3.024**
	(1.402)	(1.108)	(0.398)	(0.953)	(1.234)
Z_{it+1}^{H}				-0.980	-0.805
				(1.013)	(1.988)
Z_{it+2}^{H}					-0.245
					(1.570)
Z_{it+3}^{H}					-0.299
					(0.598)
D_{it-1}^{H}	Y	Y	Y	Y	Y
Number of Observations	162,863	182,009	189,636	185,617	166,799

Notes: Standard errors in parenthesis are clustered on household: *** p < 0.01, ** p < 0.05, * p < 0.10. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-month dummies.

Table C.4 Regression of Quarterly Consumption Growth on Constructed Wealth Shock

Dependent Variable: ΔC_{it}	(1)	(2)	(3)	(4)
Z_{it}^{H}	0.537*	0.703**	0.932**	
	(0.312)	(0.329)	(0.470)	
Z_{it}^{H-exp}				0.255
				(0.280)
$Z_{it}^{H-unexp}$				0.745
				(0.613)
D_{it-1}^{H}	-0.006***		-0.016	-0.006***
	(0.001)		(0.010)	(0.001)
$\boldsymbol{a_{it-1}^{H}}/W_{it-1}$		-0.026***		
		(0.006)		
Fixed-Effect	N	N	Y	N
Num. of Obs.	58,911	58,911	58,911	58,911

Notes: Standard errors in parenthesis are clustered on household: *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.10. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of year-quarter dummies

Table C.5 Regression of Semi-Annual Consumption Growth on Constructed Wealth Shock

Dependent Variable: ΔC_{it}	(1)	(2)	(3)	(4)
Z_{it}^{H}	0.304	0.341	0.894**	
	(0.286)	(0.256)	(0.387)	
Z_{it}^{H-exp}				0.0667
				(0.333)
$Z_{it}^{H-unexp}$				0.847
				(0.904)
D_{it-1}^{H}	-0.010***		-0.016	-0.009***
	(0.002)		(0.017)	(0.002)
$\boldsymbol{a_{it-1}^{H}}/W_{it-1}$		-0.0251		
		(0.023)		
Fixed-Effect	N	N	Y	N
Num. of Obs.	25,612	25,612	25,612	25,612

Notes: Standard errors in parenthesis are clustered on household: *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.10. Top and bottom 0.5 percent of $\Delta a_{it}/W_{it-1}$ are recoded to missing. All regressions include the following additional controls: age, age-squared, dummies for occupation, size of household, the number of children, dummies for educational attainment, and a full set of each six-month dummies

C.3 Identification of Model Parameters

The model is identified by imposing variance-covariance restrictions on the process of income and consumption growth. The identification of the idiosyncratic income components and their impacts on consumption is well defined in BPP, and thus we follow their identification strategy. However, we introduce more flexibility in the model structure and reflect heterogeneity across households. These would impose additional difficulties. Thus, in order to improve the precision of estimation, we include additional moment conditions.

The parameters governing the income process can be identified by using the following covariance restrictions in panel data:

$$cov(\Delta y_{it}, \Delta y_{it-s}) = \begin{cases} var(\zeta_{it}) + var(\varepsilon_{it}) + (\theta-1)^2 var(\varepsilon_{it-1}) + \theta^2 var(\varepsilon_{it-2}) & \text{for } s = 0 \\ (\theta-1)var(\varepsilon_{it-1}) + \theta(1-\theta)var(\varepsilon_{it-2}) & \text{for } s = 1, \\ -\theta var(\varepsilon_{it-2}) & \text{for } s = 2, \end{cases}$$

where $var(\cdot)$ denotes cross-sectional variances. Given that v_{it} follows a MA(1) process, $cov(\Delta y_{it}, \Delta y_{it+s}) = 0$ whenever $s > 2$.

Covariances of consumption and income growth can be used to identify the insurance-related parameters:

$$cov(\Delta y_{it}, \Delta c_{it-s}) = \begin{cases} E(\phi_{it})var(\zeta_{it}) + E(\psi_{it})var(\varepsilon_{it}), & \text{for } s = 0 \\ E(\psi_{it-1})(\theta-1)var(\varepsilon_{it-1}) & \text{for } s = 1, \\ -\theta E(\psi_{it-2})var(\varepsilon_{it-2}) & \text{for } s = 2, \end{cases}$$

where $cov(\Delta y_{it}, \Delta c_{it-s})$ becomes zero if $s > 2$. The covariance moment $cov(\Delta y_{it}, \Delta c_{it-s})$ has been used in the literature as a test for advanced information in the income process (**?**). The idea is that, if future income shocks in $t + s$ were known to the consumer in earlier periods, then consumption should adjust before the observed shock occurs and this should result in significant auto-covariances $cov(\Delta y_{it+s}, \Delta c_{it})$.

With the insurance and income shocks, the variance of consumption innovation $\sigma^2_{\xi_{it}}$ can be identified by using variance of consumption growth:

$$var(\Delta c_{it}) = E(\phi^2_{it})var(\zeta_{it}) + E(\psi^2_{it})var(\varepsilon_{it}) + var(\xi^2_{it}) \tag{C.5}$$

However, as the model allows the income shocks and consumption insurance to vary over i and t, these cause difficulties in empirically estimating the parameters which govern the changes of ϕ_{it} and ψ_{it}. In other words, the covariances of consumption and income growth provide the average of insurability over households, and these averaging out procedure would result in significant loss of household heterogeneity and may cause inappropriate identification of model parameters. Thus, in order to add identification conditions in a feasible manner and improve the efficiency of estimating procedure, we calculate the marginal effect of each time-varying individual covariates in X^m_{it-s} and consider average marginal effects (AME).

$$\partial var(\Delta y_{it}|X^m_{it-1})/\partial X^m_{it-1,j} = \partial E((\Delta y_{it})^2|X^m_{it-1})/\partial X^m_{it-1,j}$$

$$\partial cov(\Delta y_{it}, \Delta y_{it-s}|X^m_{it-s-1,j})/\partial X^m_{it-s-1,j} = \begin{cases} \partial E(\Delta y_{it}, \Delta c_{it-s}|X^m_{it-s-1})/\partial X^m_{it-s-1,j}, & \text{for } 1 \leq s \leq 2 \\ 0, & \text{for } s > 2, \end{cases}$$

$$\partial var(\Delta c_{it}|X^m_{it-1})/\partial X^m_{it-1,j} = \partial E((\Delta c_{it})^2|X_{it-1})/\partial X^m_{it-1,j}$$

$$\partial cov(\Delta y_{it}, \Delta c_{it-s}|X^m_{it-s-1})/\partial X^m_{it-s-1,j} = \begin{cases} \partial E(\Delta y_{it}, \Delta c_{it-s}|X^m_{it-s-1})/\partial X^m_{it-s-1,j}, & \text{for } 0 \leq s \leq 2 \\ 0, & \text{for } s > 2, \end{cases}$$

where $\partial(\cdot)/\partial X^m_{it-k,j}$ captures the changes in $(\cdot)$ for a one-unit change in the j-th covariate.

Empirical moment conditions m^e: As the auto-covariance of income and consumption growth and the covariance between income and consumption growth are used for the identification of model parameters, estimated variance-covariance of income and consumption growth is a part of empirical moment conditions m^e.[5] These lead us with 730-moment conditions (323- and 407-moment conditions for the first and second panel, separately).

Also, considering the model assumption on ϕ_{it}, ψ_{it}, $\sigma^2_{\zeta_{it}}$, $\sigma^2_{\varepsilon_{it}}$ and $\sigma^2_{\xi_{it}}$, the moment conditions of average marginal effects (AME) under the baseline specification are related with squared Δy_{it} and Δc_{it} and interaction between Δy_{it} and Δc_{it} and can

[5] As it is assumed that the transitory component ν_{it} of residual income difference follows MA(1) process, We use $var(\Delta c_{it})$, $cov(\Delta y_{it}, \Delta y_{it-k})$, and $cov(\Delta c_{it}, \Delta y_{it-k})$, $k \in \{0, 1, 2\}$.

be empirically estimated by equation (C.6) and (C.10).

$$(\Delta y_{it})^2 = \alpha_1^y + \alpha_2^y Z_{it-1}^{H-prev} + \alpha_3^y Z_{it-2}^{H-prev} + \alpha_4^y Z_{it-3}^{H-prev} + \alpha_5^c D_{it-1}^H + \alpha_6^c D_{it-2}^H + \alpha_7^c D_{it-3}^H + \tau_t + \varpi_{it}^y \tag{C.6}$$

$$\Delta y_{it} \cdot \Delta y_{it-1} = \alpha_1^{yy1} + \alpha_2^{yy1} Z_{it-2}^{H-prev} + \alpha_3^{yy1} Z_{it-3}^{H-prev} + \alpha_4^{yy1} D_{it-2}^H + \alpha_5^{yy1} D_{it-3}^H + \tau_t + \varpi_{it}^{yy1} \tag{C.7}$$

$$\Delta y_{it} \cdot \Delta y_{it-2} = \alpha_1^{yy2} + \alpha_2^{yy2} Z_{it-3}^{H-prev} + \alpha_3^{yy2} D_{it-3}^H + \tau_t + \varpi_{it}^{yy21} \tag{C.8}$$

$$(\Delta c_{it})^2 = \alpha_1^c + \alpha_2^c Z_{it-1}^{H-prev} + \alpha_3^c D_{it-1}^H + \alpha_4^c Age_{it} + \alpha_5^c (Z_{it-1}^{H-prev})^2 + \alpha_6^c Age_{it}^2 + \tau_t + \varpi_{it}^c \tag{C.9}$$

$$\Delta y_{it} \cdot \Delta c_{it-s} = \alpha_1^{yc} + \alpha_2^{yc} Z_{it-s-1}^{H-prev} + \alpha_3^{yc} D_{it-s-1}^H + \alpha_4^{yc} Age_{it-s} + \tau_{t-s} + \varpi_{it}^s, \quad s \in \{0,1,2\} \tag{C.10}$$

where τ_t denotes a set of full month-year dummies.

The AME is derived by differentiating equation (C.6) and (C.10) with time-varying individual covariates as follows:

$$m_{\Delta y_{it}^2, j} = \partial E((\Delta y_{it})^2 | I_{it-1}) / \partial X_{it-1,j} \tag{C.11}$$

$$m_{\Delta y_{it} \Delta y_{it-1}, j} = \partial E(\Delta y_{it} \cdot \Delta y_{it-1} | I_{it-2}) / \partial X_{it-2,j} \tag{C.12}$$

$$m_{\Delta y_{it} \Delta y_{it-2}, j} = \partial E(\Delta y_{it} \cdot \Delta y_{it-2} | I_{it-3}) / \partial X_{it-3,j} \tag{C.13}$$

$$m_{\Delta c_{it}^2, j} = \partial E((\Delta c_{it})^2 | I_{it-1}) / \partial X_{it-1,j} \tag{C.14}$$

$$m_{\Delta y_{it} \Delta c_{it-s}, j} = \partial E(\Delta y_{it} \cdot \Delta c_{it-s} | I_{it-s-1}^m) / \partial X_{it-s,j}^m, \quad s \in \{0,1,2\} \tag{C.15}$$

Under the baseline specification, the above calculation adds 18 moment conditions separately for the first and second panel. Thus, this leads us with 766 empirical moment conditions in total (first panel: 341 / second panel: 425).

Constructed moment conditions m^c: Based on the model assumptions, the list of constructed moment conditions corresponding to identification of using auto-covariance and covariance between income and consumption growth are expressed by equation (C.16)-(C.22):

$$var(\Delta y_{it}) = E_t[\sigma^2_{\zeta_{it}} + \sigma^2_{\varepsilon_{it}} + (\theta-1)^2\sigma^2_{\varepsilon_{it-1}} + \theta^2\sigma^2_{\varepsilon_{it-2}}] \quad (C.16)$$

$$cov(\Delta y_{it}, \Delta y_{it-1}) = E_t[(\theta-1)\sigma^2_{\varepsilon_{it-1}} + \theta(1-\theta)\sigma^2_{\varepsilon_{it-2}}] \quad (C.17)$$

$$cov(\Delta y_{it}, \Delta y_{it-2}) = -\theta E_t[\sigma^2_{\varepsilon_{it-2}}] \quad (C.18)$$

$$var(\Delta c_{it}) = Var_t[E(\Delta c_{it}|X_{it})] + E_t[Var(\Delta c_{it}|X_{it})] = E_t(\phi^2_{it}\sigma^2_{\zeta_{it}} + \psi^2_{it}\sigma^2_{\varepsilon_{it}} + \sigma^2_{\xi_{it}}) \quad (C.19)$$

$$cov(\Delta y_{it}, \Delta c_{it}) = E_t[\sigma^2_{\zeta_{it}}\phi_{it} + \sigma^2_{\varepsilon_t}\psi_{it}] \quad (C.20)$$

$$cov(\Delta y_{it}, \Delta c_{it-1}) = (\theta-1)E_t[\sigma^2_{\varepsilon_{it-1}}\psi_{it-1}] \quad (C.21)$$

$$cov(\Delta y_{it}, \Delta c_{it-2}) = -\theta E_t[\sigma^2_{\varepsilon_{it-2}}\psi_{it-2}] \quad (C.22)$$

Expectation of below equations (C.23)-(C.25) show the constructed moment conditions related to AME:

$$\partial var(\Delta y_{it})/\partial X_{it-1,j},\ \partial cov(\Delta y_{it}, \Delta y_{it-1})/\partial X_{it-2,j},\ \partial cov(\Delta y_{it}, \Delta y_{it-2})/\partial X_{it-3,j}, \quad (C.23)$$

$$\partial var(\Delta c_{it})/\partial X_{it-1,j},\ \partial cov(\Delta y_{it}, \Delta c_{it})/\partial X_{it-1,j},\ \partial cov(\Delta y_{it}, \Delta c_{it-1})/\partial X_{it-2,j}\ , \quad (C.24)$$

$$\partial cov(\Delta y_{it}, \Delta c_{it-2})/\partial X_{it-3,j} \quad (C.25)$$

Vector of moment conditions: m^e and m^c are the vector of empirical and constructed moment conditions which stack on the moment conditions explained above. for the first and second panels, separately. The list of moment conditions is summarized as:

$$m^j = \begin{bmatrix} m^j_2 \\ m^j_3 \\ : \\ m^j_{T_l} \\ m^j_{add} \end{bmatrix}, m^j_t = \begin{bmatrix} var(\Delta y_{it}) \\ var(\Delta c_{it}) \\ cov(\Delta y_{it}, \Delta c_{it}) \\ cov(\Delta y_{it}, \Delta y_{it-1}) \\ cov(\Delta y_{it}, \Delta c_{it-1}) \\ cov(\Delta y_{it}, \Delta y_{it-2}) \\ cov(\Delta y_{it}, \Delta c_{it-2}) \end{bmatrix}, m^j_{add} = \begin{bmatrix} E[\partial var(\Delta y_{it})/\partial X^m_{it-1}]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta y_{it-1})/\partial X^m_{it-2}]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta y_{it-2})/\partial X^m_{it-3}]' \\ E[\partial var(\Delta c_{it})/\partial X^m_{it-1}]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it})/\partial X^m_{it-1}]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it-1})/\partial X^m_{it-2}]' \\ E[\partial cov(\Delta y_{it} \cdot \Delta c_{it-2})/\partial X^m_{it-3}]' \end{bmatrix}$$

$$j \in \{e, c\} \quad (C.26)$$

where X^m_{it-s} is a vector of household specific variables which govern the income process and consumption insurance. $l = 1$ ($l = 2$) if the data come from the first (second) panel.

Variance-covariance matrix: In order to calculate standard errors of MSM estimators, we need to derive the variance-covariance (var-cov) matrix V of empirical moment conditions m^e. The construction of var-cov matrix of m_t^j is referred to V_1 which is well defined in BPP. As we use AME as additional moment conditions, V_2 denotes the corresponding var-cov matrix of m_{add}^j and is expressed by 18-by-18 matrix as given in equation (C.29)-(C.31).

$$V = \begin{bmatrix} V_1, \ \mathbf{0} \\ \mathbf{0}, \ V_2 \end{bmatrix}, \quad V_2 = \begin{bmatrix} V_{2,y_t^2}, \ \mathbf{0}, \ \mathbf{0}, \ \mathbf{0} \\ \mathbf{0}, \ V_{2,y_t \cdot y_{t-k}}, \ \mathbf{0}, \ \mathbf{0} \\ \mathbf{0}, \ \mathbf{0} \ , V_{2,c_t^2} \ \mathbf{0} \\ \mathbf{0}, \ \mathbf{0}, \ \mathbf{0}, \ V_{2,y_t \cdot c_{t-k}} \end{bmatrix} \tag{C.27}$$

$$V_{2,y_t^2} = \begin{bmatrix} var(m_{y_t^2,1}), cov(m_{y_t^2,1}, y_{c_t^2,2}) \\ cov(m_{y_t^2,1}, y_{c_t^2,2}), var(m_{y_t^2,2}) \end{bmatrix} \tag{C.28}$$

$$V_{2,y_t \cdot y_{t-k}} = \begin{bmatrix} var(\chi_2^1), \ cov(\chi_2^1, \chi_3^1), \ 0, \ 0 \\ cov(\chi_2^1, \chi_3^1), \ var(\chi_3^1), \ 0, \ 0 \\ 0, \ 0, \ , var(\chi_2^2), \ cov(\chi_2^2, \chi_3^2) \\ 0, \ 0, \ , cov(\chi_2^2, \chi_3^2), \ var(\chi_3^2) \end{bmatrix} \tag{C.29}$$

$$V_{2,c_t^2} = \begin{bmatrix} var(m_{c_t^2,1}), \ cov(m_{c_t^2,1}, m_{c_t^2,2}), \ cov(m_{c_t^2,1}, m_{c_t^2,3}) \\ cov(m_{c_t^2,1}, m_{c_t^2,2}), \ var(m_{c_t^2,2}), \ cov(m_{c_t^2,2}, m_{c_t^2,3}) \\ cov(m_{c_t^2,1}, m_{c_t^2,3}), \ cov(m_{c_t^2,2}, m_{c_t^2,3}), \ var(m_{c_t^2,3}) \end{bmatrix} \tag{C.30}$$

$$V_{2,y_t \cdot c_{t-k}} = \begin{bmatrix} var(m_{yc_t,1}), \ cov(m_{yc_t,1}, m_{yc_t,2}), \ cov(m_{yc_t,1}, m_{yc_t,3}), \ 0, \ 0, \ 0, \ 0, \ 0, \ 0 \\ cov(m_{yc_t,1}, m_{yc_t,2}), \ var(m_{yc_t,2}), \ cov(m_{yc_t,2}, m_{yc_t,3}), \ 0, \ 0, \ 0, \ 0, \ 0, \ 0 \\ cov(m_{yc_t,1}, m_{yc_t,3}), \ cov(m_{yc_t,2}, m_{yc_t,3}), \ var(m_{yc_t,3}), \ 0, \ 0, \ 0, \ 0, \ 0, \ 0 \\ 0, \ 0, \ 0, \ var(m_{yc_{t-1},1}), \ cov(m_{yc_{t-1},1}, m_{yc_{t-1},2}), \ cov(m_{yc_{t-1},1}, m_{yc_{t-1},3}), \ 0, \ 0, \ 0 \\ 0, \ 0, \ 0, \ cov(m_{yc_{t-1},1}, m_{yc_{t-1},2}), \ var(m_{yc_{t-1},2}), \ cov(m_{yc_{t-1},2}, m_{yc_{t-1},3}), \ 0, \ 0, \ 0 \\ 0, \ 0, \ 0, \ cov(m_{yc_{t-1},1}, m_{yc_{t-1},3}), \ cov(m_{yc_{t-1},2}, m_{yc_{t-1},3}), \ var(m_{yc_{t-1},3}), \ 0, \ 0, \ 0 \\ 0, \ 0, \ 0, \ 0, \ 0, \ 0, var(m_{yc_{t-2},1}), \ cov(m_{yc_{t-2},1}, m_{yc_{t-2},2}), \ cov(m_{yc_{t-2},1}, m_{yc_{t-2},3}) \\ 0, \ 0, \ 0, \ 0, \ 0, \ 0, cov(m_{yc_{t-2},1}, m_{yc_{t-2},2}), \ var(m_{yc_{t-2},2}), \ cov(m_{yc_{t-2},2}, m_{yc_{t-2},3}) \\ 0, \ 0, \ 0, \ 0, \ 0, \ 0, \ cov(m_{yc_{t-2},1}, m_{yc_{t-2},3}), \ cov(m_{yc_{t-2},2}, m_{yc_{t-2},3}), \ var(m_{yc_{t-2},3}) \end{bmatrix} \tag{C.31}$$